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2000

SELECTING PLANNING AND SCHEDULING SPECIFICATIONS FOR CONSTRUCTION PROJECTS

by

Leaf Aquilla Ballast, B.S.C.E.

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering

The University of Texas at Austin

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SELECTING PLANNING AND SCHEDULING SPECIFICATIONS FOR CONSTRUCTION PROJECTS

Dedication

I wish to dedicate this thesis to my wife, Crystal D-Ann Ballast, for the support that she has provided to me during my Naval career. Military spouses often sacrifice as much as military personnel in the defense of this great nation. She has ensured that our family always has a home no matter where the United States Navy sends us.

I also wish to dedicate this thesis to my father, Robert Charles Ballast, my mother, Marlene Cenith Ballast, and my brother, Corbin Dale Ballast for their guidance, support, and friendship throughout my life.

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Engineering Field Activity Midwest Resident Officer in Charge of Construction, Great Lakes, IL

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May 2000

Abstract

SELECTING PLANNING AND SCHEDULING SPECIFICATIONS FOR CONSTRUCTION PROJECTS

by

Leaf Aquilla Ballast, M.S.E.

The University of Texas at Austin, 2000

Supervisor: Calin M. Popescu

This thesis analyzes the effect of contract remuneration type and project complexity on the desirability of planning and scheduling specification clauses for construction projects. The information in this thesis is based on the analysis of responses to a survey that was sent to randomly selected construction companies, large owners, and various Naval Facilities Engineering Commands. For the survey, traditional definitions of lump sum and cost reimbursable contracts were used, and an easily quantifiable project complexity rating was developed. The analysis provides practical insights on which planning and scheduling specification clauses should be included for projects of different complexities and remuneration types. It also provides valuable insights on the differences in how contractors and owners view each planning and scheduling specification clause. Conclusions and recommendations are presented based on the results of the analysis.

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Chapter 1: Introduction

1.1 Purpose

The purpose of this thesis is to determine how construction project complexity and contract remuneration type affect the desirability of planning and scheduling specification clauses.

A comprehensive planning and scheduling specification is a system that can truly aid planning of job sequences, financial needs, manpower needs, material needs, and equipment needs. It can aid scheduling of actual activity start or completion and provide feedback to control the schedule, cost, and use of resources (Fairchild 1985). A critical step in the execution of any construction project is the selection of planning and scheduling specification clauses to be included in the construction contract. Numerous project characteristics should be taken into account when determining which planning and scheduling specification clauses should be included. Two major items to take into consideration are project complexity and contract remuneration type. This thesis will explore how these attributes affect the desirability of planning and scheduling specification clauses by both owners and contractors.

For the purpose of this research, the following attributes define project complexity:

- Estimated number of construction activities
- Estimated number of subcontractors
- Number of CSI Divisions
- Estimated cost of installed equipment (i.e. long lead items such as transformers, elevators, HVAC equipment, et cetera)
- Project priority

The following contract remuneration types are also considered in this research:

- Lump sum contracts (i.e. unit price and fixed price with escalation)
- Cost reimbursable contacts (i.e. cost plus a percentage fee, cost plus a fixed fee, cost plus an incentive fee, and cost plus an award fee).

1.2 Scope

The scope of this research is to collect subjective data on selecting planning and scheduling (P&S) specification clauses for construction projects based on combinations of project complexity and contract remuneration type. The data was collected from randomly selected contractors, owners, and U.S. Navy Facilities Engineering Field Divisions and Engineering Field Activities. The research focuses on new construction projects that are well defined.

1.3 Hypothesis

There is a scarcity of actual research on selecting P&S specification clauses for construction projects based on project attributes such as complexity and contract remuneration type. This thesis lists 49 P&S specification clauses for selection in a construction contract. The following hypotheses will be used:

a. Project complexity rating directly affects the number of P&S specification clauses selected by both owners and contractors. A project with a high complexity rating will result in the selection of more clauses than a project with medium or low complexity rating.

b. Contract remuneration type affects the number of P&S specification clauses selected. For both owners and contractors, cost reimbursable contracts will result in the selection of more clauses than lump sum contracts.

Chapter 2: Background

The information gathered in this chapter was collected through an extensive literature review. It discusses the content of the planning and scheduling specifications utilized in this research. Basic definitions of project complexity rating and the two types of contract remuneration researched will be provided. Lastly, past research conducted on planning and scheduling specifications will be examined.

2.1 Planning and Scheduling Specification Clauses

The planning and scheduling (P&S) specification clauses used in this thesis fall into one of the following sections: 1) General Organization and Responsibility; 2) Scope and Products; or 3) Progress Monitoring and Updating. The P&S specification clauses can be seen in their entirety in Appendix A. Each of these sections also serves as a general category of P&S specification clauses.

2.1.1 General Organization and Responsibilities

The intentions of the clauses in this section fall into one of the following categories:

- General Description
- Responsibility, Qualifications, and Training
- Scheduling Deadlines, Costs, and Audits
- Schedule Ownership and Security

The General Description clauses describe the phase and/or portions of the project that are required to be tracked in the schedule. These included but are not limited to the following: detailed design, design reviews, land acquisition, major material and equipment procurement, field erection/installation, final startup, et cetera. These clauses also list references and standards associated with CPM scheduling.

The clauses associated with Responsibility, Qualifications, and Training specify the following:

- Responsibility for the development and maintenance of the network logic diagram;
- The minimum education and/or experience qualifications for the planning and scheduling staff; and
- The CPM training requirements for project management personnel (i.e. owner's representatives, contractor personnel, and subcontractor personnel).

The next category of clauses for this section is Scheduling Deadlines, Costs, and Audits. Clauses in this category will specify deadlines for submission of preliminary and detailed networks and the review and approval process for these networks. This category also contains clauses that specify a monetary amount to be applied to planning/scheduling and monitoring and how payment to the contractor will be made for performing these functions. Other clauses deal

with the following: which subcontractors will have input into the schedule, the contractor's scheduling plan, and planning/scheduling and monitoring audits.

The final category of General Organization and Responsibilities section is Schedule Ownership and Security. It essentially specifies who owns the schedule, whether or not the schedule is confidential, and if computer access and security are required.

2.1.2 Scope and Products

The intentions of the clauses in this section fall into one of the following categories:

- Network Analysis and Scope
- Reports Information
- Network Detail and Scope

The Network Analysis and Scope clauses specify the network analysis technique to be used such as Arrow Diagramming Method, Precedence Diagramming Method, or PERT. In most cases, the Precedence Diagramming Method is used in construction today. Other clauses in this category will specify the type of CPM software to be used (if any) and whether or not Resource Aggregation, Leveling, and/or Allocation will be performed.

The clauses in the Reports Information category require the contractor to input information into each activity; such as, descriptions, durations, coding

systems, and responsibility codes, so that construction activities can be sorted and reports produced that give a good snapshot of the status of the project. Project Breakdown Structure, Activity Sorting Requirements, and Required Reports for Initial Submission are also specified in this category.

The clauses in the Network Detail and Scope category specify the level of detail for the network; such as, maximum activity duration, maximum activity cost, and minimum number of activities in the total network. These clauses are intended to ensure that the contractor's construction planning effort is satisfactory by specifying a level of detail for the network diagram (Zack 1992). This category includes clauses that specify the scope of the contractor's summary schedule, preliminary network, and detailed network. The network diagram drafting requirements are also specified.

2.1.3 Progress Monitoring and Updating

As seen in the title of this section, the subject clauses specify how progress monitoring of the project and updating of the network shall be accomplished. This section includes clauses that specify how often the network shall be updated, who participates in update meetings, what has to be included in each update, the update turnover time, and the required reports after each update. This section also includes clauses on float management (i.e. who owns it) and how change orders shall be represented in the network.

2.2 Project Complexity Rating

Complexity is a term that is often subjectively applied to construction projects. Webster's Third New International Dictionary defines complex as "having many varied interrelated parts, patterns, or elements and consequently hard to understand fully." Selected experts in the building industry view a complex project as follows (Gidado 1996):

a. That having a large number of different systems that need to be put together and/or that with a large number of interfaces between elements.

b. When a project involves construction work on a confined site with access difficulty and requiring many trades to work in close proximity and at the same time.

c. That with a great deal of intricacy which is difficult to specify clearly how to achieve a desired goal or how long it would take.

d. That which requires a lot of details about how it should be executed.

e. That which requires efficient coordinating, control, and monitoring from start to finish.

f. That which requires a logical link because a complex project usually encounters a series of revisions during construction and without interrelationships between activities it becomes very difficult to successfully update the program in the most effective manner.

This research attempts to objectively quantify project complexity by developing a project complexity rating that is determined by the following attributes:

- Estimated number of construction activities in the network diagram
- Estimated number of subcontractors expected to be utilized during the construction of the project
- Estimated number of CSI Divisions included in the specification
- Estimated cost of installed equipment (long lead items such as transformers, elevators, HVAC equipment, et cetera)
- Project priority

All of these attributes correlate either directly or indirectly with at least one of the previously listed characteristics of a complex project as expressed by Gidado's building industry experts.

The project complexity rating developed in this research allows for three possible levels of project complexity: high, medium, and low. Each attribute was given an objective value that corresponds to each of the levels stated above. The only exception is project priority, which is entirely subjective. Table 2.1 shows values required for each attribute to achieve a complexity rating of high, medium, and low.

Table 2.1: Complexity Rating

	Complexity Rating		
Attributes	**High**	**Medium**	**Low**
NA = No. of Const. Activities	**NA** > 1,000	100 < **NA** ≤ 1,000	**NA** ≤ 100
NS = No. of Subcontractors	**NS** > 20	10 < **NS** ≤ 20	**NS** ≤ 10
ND = No. of CSI Divisions	**ND** > 13	7 < **ND** ≤ 13	**ND** ≤ 7
CE = Cost of Installed Equip	**CE** > $250,000	$50,000 < **CE** ≤ $250,000	**CE** ≤ $50,000
PP = Project Priority	**PP** = High	**PP** = Medium	**PP** = Low

2.3 Contract Remuneration Types

This research examines what effect lump sum and cost reimbursable contracts have on the desirability of P&S specification clauses.

A lump sum contract is a guarantee by the contractor to perform the work, as specified, for a fixed price no matter what the actual price may be (The Business Roundtable Report A-7 1982). The variations include (Nesius 1998):

- Unit Price – unit costs and estimated quantities with payments based on work actually performed.
- Fixed Price with Escalation – price adjustments on cost of certain materials, labor or other factors beyond the contractor's control.
- Incentives may also be used in conjunction with a lump sum contract.

A cost reimbursable contract is an agreement by the contractor to perform the work and be reimbursed on the basis of actual costs incurred for material and labor, plus an agreed amount for the contractor's overhead and profit (The Business Roundtable Report A-7 1982). The "agreed amount" is often referred to as the "fee." Variations of cost reimbursable contracts include (Nesius 1998):

- Cost plus a Percentage Fee – the contractor's fee is a percentage of the actual project cost.
- Cost plus a Fixed Fee – a fee covering the contractor's overhead and profit if negotiated before the project commences.
- Cost plus an Incentive Fee – some or the entire fee is dependent upon achieving certain cost, schedule or other goals.
- Cost plus an Award Fee – fee varies according to certain agreed criteria on which the contractor is rated for performance.
- Guaranteed Maximum Price – similar to cost plus a fixed fee except that a ceiling is set for 100% cost reimbursement to the contractor.

This research will examine all variations of lump sum and cost reimbursable contracts as a whole. The variations of each type of contract will not be evaluated independently as to what effect they have on the desirability of P&S specification clauses.

2.4 Past Research

While there has been some research accomplished on developing P&S (or CPM) specifications for construction projects, very little research has been completed on selecting P&S specification clauses. P&S specifications can vary from being a brief paragraph stating the Contractor will use CPM to being many pages stating how the Contractor is to use CPM. Projects with different cost, scale, and complexity may require varying degrees of control, thus, different P&S specification clauses should be required to meet these varying degrees of control (Fairchild 1985).

A first-rate P&S specification considers the objectives of all of the principal parties involved in the project; Owner, Architect/Engineer, General Contractor, and Subcontractors. Each party has different goals or objectives in their use of the P&S specification system. Each party will be more committed to carry out their required P&S obligations if the P&S specifications meet each party's objectives and goals (Fairchild 1985). This is a recurring theme in much of the literature published on P&S specifications. These systems are only as good as the Contractor and Owner's motivation to implement them.

A balance has to be found on the level of detail of the P&S specification system. P&S specifications that are too brief are likely to cause problems as well as specifications that are too cumbersome or too detailed (Popescu 1987).

P&S specification clauses can cause problems if they are not properly worded, applied, or adhered to. A report to the Construction Industry Institute on the impact of clauses on project performance states *"Clauses related to work scope definition, changes, and project control are the most frequent source of disputes and poor project performance"* (Ashley 1986).

Many of the clauses in P&S specifications can be used to remedy schedule "Games" people play. For instance, using a clause specifying progress payment for a Contractor's Planning and Scheduling effort can motivate a contractor to keep the schedule updated. Other clauses that can also help remedy other "games" are minimum/maximum number of activities, maximum activity duration requirement, and interim milestone dates (Zack 1992)

This research looks at all of the P&S specification clauses contained in Appendix A and asks Contractors and Owners if they would include the clauses given a notional project with a specified level of complexity. This will provide insights as to which clauses Contractors and Owner like and which ones they do not like.

Chapter 3: Research Methodology

This chapter will discuss the methodology used to conduct the research contained in this thesis. The source of data for this thesis is briefly discussed followed by a description of techniques used to analyze the data.

3.1 Survey

The data for this thesis was collected by sending surveys to contractors, owners, and U.S. Naval Facilities (NAVFAC) Engineering Field Divisions (EFD) and Engineering Field Activities (EFA). Fifty contractors and fifty owners were randomly selected from *Engineering News Record's* top 100 contractors and owners. One survey participant from each NAVFAC EFD and EFA (a total of eight) was selected to complete the survey.

The survey consisted of four parts: 1) a cover letter, 2) instructions on how to complete the survey, 3) the actual survey, and 4) sample planning and scheduling guide specifications. The sample specification and the full version of the instructions is contained in Appendices A and B respectively.

The aforementioned purpose of this thesis is to determine how construction project complexity and contract remuneration type affect the desirability of planning and scheduling specification clauses. Therefore, project complexity and remuneration type had to be defined and incorporated into the

survey. These attributes for both complexity and remuneration type were defined in Chapter 2 of this thesis.

A list and brief description of the P&S specification clauses considered in this thesis follows. The complete wording of each clause is contained in Appendix A.

No.	Description of Clause
1.1	Description, References, Standards
1.2	Scheduling Responsibility
1.3	Minimum Qualifications of Planning and Scheduling Staff
1.4	Training Requirement for Contractor, Subcontractor, Owner
1.5	Preliminary Network Submission Deadline
1.6	Detailed Network Submission Deadline
1.7	Review and Approval Process
1.8	Cost of Planning/Scheduling and Monitoring
1.9	Progress Payments for Planning/Scheduling and Monitoring
1.10	Subcontractor Input
1.11	Contractor's Scheduling Plan
1.12	Planning/Scheduling and Monitoring Audits
1.13	Confidentiality/Schedule Ownership
1.14	Computer Access and Security
2.1	Network Analysis Technique
2.2	CPM Software (or equal) to be Used
2.3.1	Activity Description
2.3.2	Activity Duration (Time Units)
2.3.3	Activity Coding System
2.3.4	Responsibility Codes
2.3.5	Activity Level Resources
2.3.6	Project Level Resources
2.3.7	Activity Costs
2.3.8	Work Calendars
2.4.1	Maximum Activity Duration
2.4.2	Maximum Activity Costs
2.4.3	Minimum Number of Activities in the Completed Network
2.4.4	Minimum Number of Activities in the Preliminary Network
2.5.1	Summary Schedule

2.5.2 Preliminary Network
2.5.3 Detailed Network
2.6 Project Breakdown Structure
2.7 Milestones and Imposed Dates
2.8 Activity Sorting Requirements
2.9 Drafting Requirements
2.10 Required Reports for Initial Submittal of Completed Network
2.11.1 Resource Aggregation
2.11.2 Resource Leveling
2.11.3 Resource Allocation Optimization
3.1 Updating Frequency
3.2 Updating Participation
3.3 Updated Network Approval
3.4 Updating Turnover Time
3.5 Updating Records and Reporting
3.6 Float Management
3.7.1 Change Order Representation
3.7.2 Change Order Summary/Documentation
3.7.3 Timing of Change Order Incorporation
3.8 Required Reports at Each Update

The cover letter asked that respondents to the survey should have ten years of experience as a project manager on various sized projects and experience using computerized scheduling software. The respondents were tasked with choosing six notional projects containing the attributes listed in Table 3.1 and determining the desirability of each P&S specification clause based on their expert opinion and experience. For each notional project, the respondent marked one of the following responses for each clause:

- *Y – Yes, respondent feels strongly that this clause should be included in the specification;*
- *N – No, respondent feels strongly that this clause should not be included in the specification; or*
- *U – Undecided, respondent is undecided as to whether this clause should be included in the specification.*

Table 3.1: Project Attributes for Survey

Project	Complexity Rating	Remuneration Type
1.	High	Lump Sum
2.	Medium	Lump Sum
3.	Low	Lump Sum
4.	High	Cost Reimbursable
5.	Medium	Cost Reimbursable
6.	Low	Cost Reimbursable

Five contractors, two owners, and eight NAVFAC EFDs and EFAs completed the surveys and returned them. This research will analyze those 15 responses.

3.2 Key Definitions

This section covers a couple of key definitions that are very important to the understanding of this research.

3.2.1 Specification Desirability Rating

The Specification Desirability (SD) rating measures each respondent affinity toward the specification as a whole. As mentioned previously in this section, each respondent can choose from among three responses for each clause on each notional project. There are six total notional projects: three Lump Sum projects, and three Cost Reimbursable projects. The following points were given to each response:

- *Yes = 3.0*
- *Undecided = 1.5*
- *No = 0.0*

To calculate the Specification Desirability (SD) rating, the following steps were completed:

- *Total a respondent's scores for a notional project (e.g. high complexity/lump sum) based on the points above*
- *Divide the total by the number of clauses responded to (maximum of 49)*

3.2.2 Clause Desirability Rating

The Clause Desirability (CD) rating measures the average desirability of each clause for a notional project. The same point system that was used for SD rating was used for CD rating. To calculate Clause Desirability (CD) rating, the following steps were completed:

- *Total all of the responses for a clause for a notional project based on the points above*
- *Divide the total by the number of respondents that provided input (maximum of 15)*

3.3 Analysis Techniques

Once the surveys were returned from the respondents, the data was input into the tables listed in Appendices C, D, E, F, G, and H. There is an appendix for each notional project listed in Table 3.1 All of the data analysis performed in this research can be retrieved from these appendices.

The following items were studied to determine what effect, if any, project complexity and contract remuneration type have on the selection of P&S specification clauses:

- Determine if project complexity affects the number of P&S clauses selected.
- Determine if contract remuneration type affects the number of P&S clauses selected.

- Determine which clauses show statistically significant evidence that there is a relationship between the desirability of that clause and project complexity.

- Determine which clauses show statistically significant evidence that there is a relationship between the desirability of that clause and contract remuneration type.

- Determine if there is a statistically significant difference in the number and specific clauses that contractors and owners prefer.

The following statistical methods will be utilized to establish the relationships listed above: Analysis of Variance (ANOVA) and Contingency Tables.

3.3.1 Analysis of Variance (ANOVA)

The purpose of one-way ANOVA is to evaluate the statistical significance of differences between two or more sample means. This procedure evaluates the differences in means by analyzing variances (Diekhoff 1996). The following three assumptions are made when dealing with ANOVA: 1) the population is approximately normally distributed, 2) population variances are equal, and 3) the samples are independent and random.

To test whether the population is approximately normally distributed, a Chi-square goodness of fit test was used. The following rule of thumb test was used to determine if the samples represent population variances that are approximately equal: $2s^2_{min} \leq s^2_{max}$, where s^2_{min} and s^2_{max} are the minimum and

maximum sample variances. A two sample F-test to compare two population variations was also performed to check to see if population variances are approximately equal. Since the respondents for the survey were randomly selected, the samples are both independent and random.

If the assumptions are substantiated, ANOVA is performed on the data. A confidence interval of 95% or $\alpha = 0.05$ is used. An $\alpha = 0.05$ means that the probability of Type I error, rejecting the null hypothesis when it is true, is 5%. The null hypothesis (H_o) states that the population means are equal, the alternate hypothesis (H_a) states that population means are not equal.

H_o is accepted when either of the following conditions are met:

- Condition one: *P-value* $< \alpha$ and $F < F\ crit$, or
- Condition two: *P-value* $> \alpha$

The following condition has to be met in order to reject H_o and accept H_a:

- Condition: *P-value* $< \alpha$ and $F > F\ crit$

3.3.2 Contingency Tables

A contingency table can be used to analyze the relationship between two variables. The relationship is established by comparing observed frequencies (f_o) to expected frequencies (f_e). The observed frequencies were collected from the

data provided by the respondents, and the expected frequencies were calculated based on row and column totals.

Expected frequencies are calculated as follows:

$$f_e \text{ for position row } i \text{ column } j = \frac{(\text{row } i \text{ total}) \times (\text{column } j \text{ total})}{\text{grand total for contingency table}}$$

Once all of the f_o and f_e have been established, a chi-square (χ^2) significance test is performed. Chi-square is calculated as follows:

$$\chi^2 = \sum \frac{(f_o - f_e)}{f_e}$$

Any chi-square value that is greater than zero shows evidence that there is a relationship between the two variables; however, this relationship may or may not be statistically significant.

The null hypothesis (H_o) states that no relationship exists between the two variables, and the alternative hypothesis (H_a) states that a relationship between the two variables exists. To test this hypothesis, the calculated chi-square value is compared to a critical value of χ^2. The critical χ^2 value is based on the degree of freedom (df) of the contingency table and a selected level of significance (α). If the calculated value of χ^2 is greater than the critical value of χ^2, then H_o is rejected.

While the chi-square test will reveal that a relationship exists between the two variables, it will not reveal the strength of that relationship. For this, a Cramer's *V* statistic is calculated as follows:

$$V = \sqrt{\frac{\chi^2}{N(n-1)}}$$

where

V = Cramer's *V* Statistic
χ^2 = the chi-square statistic
N = the grand total for the contingency table
n = the number of rows or columns in the contingency table, whichever is smaller

Cramer's *V* statistic produces a number from zero to one. Where zero means the relationship is non-existent and one is the strongest that the relationship can be.

Chapter 4: Analysis

This chapter contains the analysis performed on the data provided in response to the survey. The main focus of the analysis is how project complexity and contract remuneration type affect the desirability of P&S specification clauses.

4.1 Clause Selection Factor: Project Complexity Rating vs. Specification Desirability Rating

This section evaluates how the Project Complexity rating affects the Specification Desirability rating and determines if a relation exists between the two. Based on the desirability scoring system in Chapter 3, a Specification Desirability (SD) rating was calculated for each respondent. In plain language, the SD rating is a measurement of each respondent's affinity for all of the P&S specification clauses as a whole. The SD rating for each respondent can be seen in Table 4.1.

Table 4.1: Specification Desirability for Respondents

	Lump Sum Contracts			Cost Reimbursable Contracts		
	High	**Medium**	**Low**	**High**	**Medium**	**Low**
Ctr-A	1.898	0.612	0.367	2.449	1.102	0.367
Ctr-B	2.204	1.469	0.857	2.388	1.592	0.857
Ctr-C	2.813	2.438	0.938	2.625	1.781	0.781
Ctr-D	2.344			2.375		
Ctr-E	1.898	1.286	0.000	1.898	1.286	0.000
Own-A	2.602	2.296	1.561	2.663	2.357	1.622
Own-B	2.296	1.684	1.561	2.296	1.684	1.561
Nav-A	2.082	1.898	1.776			
Nav-B	2.602	2.173	1.653	2.602	2.173	1.653
Nav-C	1.286	1.286	0.704	1.286	1.286	1.224
Nav-D	2.418	2.051	1.408	2.418	2.051	1.408
Nav-E	2.602	2.327	1.653	2.602	2.143	1.653
Nav-F	2.571	1.898	0.000	2.939	2.327	0.000
Nav-G	2.204	1.776	1.469	2.204	1.776	1.469
Nav-H	3.000	1.714	0.306	3.000	1.684	0.245
Mean	2.321	1.768	1.018	2.410	1.778	0.988

The data in Table 4.1 was used to determine if project complexity affects the number of clauses desired by the respondents for each notional project. If this is true, then the difference in the means for each complexity rating will be statistically significant. ANOVA was used to determine this.

Before ANOVA testing is performed, it is prudent to test the following assumptions that are associated with ANOVA:

- the population is approximately normally distributed
- the population variances are approximately equal
- the samples are independent and random

The Chi-square (χ^2) goodness-of-fit test was performed to see if there was a significant difference between the sample distributions and normal population distribution. In Table 4.2, the χ^2 value is less than the critical χ^2 value; therefore the difference in distributions is not significant.

The χ^2 goodness-of-fit test typically cannot be used when more than 80% of the expected frequencies are less than five. Expectant frequencies (f_e) less than five will often result in a χ^2 value that is abnormally large for a corresponding small difference between f_e and f_o. For this test, a high χ^2 value would most probably result in Type II error, which is rejecting the populations being normally distributed when they really are. However, it should have little affect on Type I error, which is accepting the populations being normally distributed when they really are not. Since the χ^2 values are small, the test was used.

Table 4.2: High Complexity/Lump Sum Projects

z-scores	Lower	Upper	%	Observed	Expected
-3 to -2	1.047	1.472	2.15%	1	0.323
-2 to -1	1.472	1.896	13.59%	0	2.039
-1 to 0	1.896	2.321	34.13%	6	5.120
0 to +1	2.321	2.746	34.13%	6	5.120
+1 to +2	2.746	3.171	13.59%	2	2.039
+2 to +3	3.171	3.596	2.15%	0	0.323
				χ^2	4.088
				Critical χ^2	9.236

The results of the Chi-square goodness-of-fit test for the other sample distributions listed in Table 4.1 are shown in Table 4.3.

Table 4.3: Summary of χ^2 Goodness of Fit Test for Lump Sum Projects

Remuneration Type	Project Complexity	χ^2	Critical χ^2	Normally Distributed?
Lump Sum	High	4.088	9.236	Yes
	Medium	4.899	9.236	Yes
	Low	4.317	9.236	Yes
Cost Reimbursable	High	3.220	9.236	Yes
	Medium	1.988	9.236	Yes
	Low	1.988	9.236	Yes

In Table 4.3, all of the χ^2 values is less than the critical χ^2 value; therefore the difference between the sample distributions and normal population distribution is not significant. This satisfies the first assumption that the populations are normally distributed.

To test the second assumption, the following rule of thumb test was used: $2s^2_{min} \leq s^2_{max}$, where s^2_{min} and s^2_{max} are the minimum and maximum sample variances. Table 4.4 shows the results of this test. Since $2s^2_{min}$ is less than s^2_{max} for both Lump Sum and Cost Reimbursable projects, it is concluded that the population variances are not significantly different.

Table 4.4: Test for Equal Variances

Remuneration Type	**$2s^2_{min}$**	**s^2_{max}**	**Variances Approx. Equal?**
Lump Sum	0.361	0.420	Yes
Cost Reimbursable	0.339	0.419	Yes

To satisfy the third assumption, the respondents were randomly selected; therefore the samples are both random and independent.

Single factor ANOVA was performed to see if the following samples means were significantly different: high vs. medium complexity, high vs. low complexity, and medium vs. low complexity. This was done for both Lump Sum

and Cost Reimbursable projects. The alpha (α) for each ANOVA was 0.05. The null (H_o) and alternative (H_a) hypotheses follow:

> H_o: *the means of the SD ratings for each complexity rating are equal for Lump Sum projects.*
>
> H_a: *the means of the SD ratings for each complexity rating are not equal for Lump Sum projects.*

As seen in Table 4.5, ANOVA provides the following terms:

- *SS* – sum of squares error
- *df* – degree of freedom
- *MS* – mean squared error
- *F* – the actual ratio of explained variation to unexplained variation
- *P-value* – the actual level of significance of ANOVA (i.e. the probability of rejecting H_o when it is true)
- *F crit* – the expected ratio of explained variation to unexplained variation

One of the following conditions has to be met in order to accept H_o and reject H_a:

- Condition one: *P-value* $< \alpha$ and *F* < *F crit*, or
- Condition two: *P-value* $> \alpha$

The following condition has to be met in order to reject H_o and accept H_a:

- Condition: *P-value* $< \alpha$ and *F* > *F crit*

Table 4.5: ANOVA of High vs. Medium Complexity for Lump Sum Projects

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
High Complexity	15	34.8195	2.3213	0.1805
Med Complexity	14	24.7538	1.7681	0.2506

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.2158	1	2.2158	10.3428	0.0034	4.2100
Within Groups	5.7845	27	0.2142			
Total	8.0004	28				

A review of Table 4.5 shows that the condition to reject H_o and accept H_a is met. Therefore, the difference between the means of the SD ratings for high and medium complexity, lump sum projects are statistically significant. Table 4.6 shows the summary of ANOVA results for Lump Sum and Cost Reimbursable projects. H_o was rejected for each case that an ANOVA was performed. This shows statistically significant evidence that there is a direct correlation between project complexity and the number of P&S specification clauses desired for both Lump Sum and Cost Reimbursable projects.

Table 4.6: Summary of ANOVA for Complexity vs. SD Rating

Remuneration Type	ANOVA	F	P-value	F_{crit}	Reject H_o?
Lump Sum	High vs. Med	10.0999	0.0038	4.2100	Yes
	High vs. Low	41.5695	6.56E-07	4.2100	Yes
	Med vs. Low	12.1465	0.0018	4.2252	Yes
Cost Reimbursable	High vs. Med	14.8812	0.0007	4.2417	Yes
	High vs. Low	45.9158	4.21E-07	4.2417	Yes
	Med vs. Low	14.2112	0.0009	4.2597	Yes

4.2 Clause Selection Factor: Lump Sum vs. Cost Reimbursable

This section evaluates how Contract Remuneration Type affects Specification Desirability (SD) rating and determines if a relation exists between the two. The data used in this section came from Table 4.1. Data from the high complexity Lump Sum notional project was compared to data from the high complexity Cost Reimbursable notional project. The same comparison was completed for both medium and low complexity projects.

The three assumptions associated with ANOVA still apply. The normal distribution and independent and random sample assumptions that were tested in Section 4.1 apply to this section, so they do not have to be tested. However, since

this section is comparing different samples than were compared in the previous section, the assumption of equal variances must be tested to see if it is true.

A two-sample F-test to compare two population variations was completed to test the assumption of equal variance. The same criteria for accepting and/or rejecting H_o and H_a for ANOVA in last apply for the F-test to compare to population variations.

H_o: the population variances are equal.

H_a: the population variances are not equal.

A review of Tables 4.7 through 4.8 show that H_o should be accepted and that H_a should be rejected. Therefore, it is concluded that the population variances are equal.

Table 4.7: Two Sample F-test for High Complexity Projects

	High - LS	*High – CR*
Mean	2.3213	2.4103
Variance	0.1805	0.1844
Observations	15	14
df	14	13
F	0.9791	
P(F<=f) one-tail	0.4821	
F Critical one-tail	0.3988	

Table 4.8: Two Sample F-test for Medium Complexity Projects

	Med – LS	*Med – CR*
Mean	1.7791	1.7877
Variance	0.2474	0.1661
Observations	14	13
df	13	12
F	1.4892	
P(F<=f) one-tail	0.2489	
F Critical one-tail	2.6602	

Table 4.9: Two Sample F-test for Low Complexity Projects

	Low - LS	*Low – CR*
Mean	1.0181	0.9879
Variance	0.4200	0.4191
Observations	14	13
df	13	12
F	1.0021	
P(F<=f) one-tail	0.5016	
F Critical one-tail	2.6602	

Since all three assumptions have tested satisfactorily, ANOVA is performed on the samples to see if there is a statistically significant difference between the means. A confidence level of $\alpha = 0.05$ was used.

H_o: *the means of the SD ratings for Lump Sum Projects and Cost Reimbursable Projects are equal for projects with the same Complexity Rating.*

H_a: *the means of the SD ratings for Lump Sum Projects and Cost Reimbursable Projects are not equal for projects with the same Complexity Rating.*

Table 4.10 is a summary of the ANOVA results. A review of this table reveals that the *P-value* for each ANOVA is greater than the confidence level at which the analysis was performed. Therefore, H_o should be accepted and H_a rejected. This shows that there is no significant evidence of a correlation between Contract Remuneration Type and the number of P&S specification clauses desired for projects of equal Complexity Rating.

Table 4.10: Summary of ANOVA Comparing Contract Remuneration Types

Project Complexity	F	P-value	F_{crit}	Reject H_o?
High	0.3149	0.5793	4.2100	No
Medium	0.0024	0.9611	4.2417	No
Low	0.0147	0.9045	4.2414	No

4.3 Clause Selection Factor: Project Complexity vs. Clause Desirability Rating

Section 4.1 established that there is a statistically significant relation between Project Complexity Rating and SD rating; however, it does not provide any information regarding specific clauses and how Project Complexity Rating

affects each clause's desirability rating. This section will analyze the relation between Project Complexity rating and Clause Desirability (CD) rating.

A contingency table was set up for each clause, and a Chi-square test of association was performed to establish if a relationship between complexity and desirability exists. A Cramer's *V* statistic was calculated to determine the strength of the relationship between complexity and desirability.

The relationship between complexity and desirability was unable to be proven statistically in many of the clauses because of the low number of respondents to the survey. The Chi-square test of association compares the number of observed frequencies to the number of expected frequencies (see Chapter 3). If more than 20% of expected frequencies in the Contingency Table are less than a quantity of five, the Chi-square test of association may not be viable (Diekhoff 1996).

Throughout the survey, use of the *"Undecided"* option was significantly less than use of either the *"Yes"* or *"No"* options. An answer of *"Undecided"* was used in only 10.6% of the responses. *"Yes"* and *"No"* were used in 52.3% and 37.1% of the responses respectively. Since the respondents used the *"Undecided"* option so infrequently, none of the contingency tables contained more than five expected frequencies for the *"Undecided"* option. Therefore, the *"Undecided"* responses were combined with the *"No"* responses in the

contingency tables. After combining these responses, 46.9% of the clauses for notional Lump Sum projects and 44.9% of the clauses for notional Cost Reimbursable projects met the criteria for a successful Chi-square test of association. Cramer's *V* statistic was also calculated for each clause to measure the strength of the relationship between project complexity and clause desirability.

4.3.1 Lump Sum Projects

The degree of freedom *df* for each Contingency Table is two. For this research, the χ^2 test of association was evaluated at a confidence level of $\alpha = 0.05$. This produces a χ^2 critical value of 5.99. The null (H_o) and alternative (H_a) hypotheses are stated below:

> *H_o: no relationship exists between Project Complexity Rating and Clause Desirability Rating*
>
> *H_a: a relationship exists between Project Complexity Rating and Clause Desirability Rating*

The following condition has to be met in order to accept H_o and reject H_a:

- Condition: $\chi^2 < 5.99$

The following condition has to met in order to reject H_o and accept H_a:

- Condition: $\chi^2 \geq 5.99$

Tables 4.11 through 4.13 are Contingency Tables for the Lump Sum project clauses with the three highest Cramer's *V* statistic in which the f_e criteria

was met. The values in parentheses in each table are the expected frequencies. All of the Contingency Tables that met the Chi-square criteria for expected frequencies are included in Appendix I.

Table 4.11: Contingency Table for Clause No. 1.3 as a Lump Sum Project

Clause Title: Minimum Qualifications of Planning and Scheduling Staff		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	13 (6.6)	2 (8.4)	15
	Medium	5 (6.2)	9 (7.8)	14
	Low	1 (6.2)	13 (7.8)	14
	Totals	19	24	43
	χ^2	19.17		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.668		

A review of Table 4.11 shows that the condition to reject H_o and accept H_a is met. Therefore, for Lump Sum projects, the desirability of clause *"1.3 Minimum Qualifications of Planning and Scheduling Staff"* is related to project complexity. Further review of Table 4.11 shows that the relationship is a direct one (i.e. desirability increases as complexity increases and vice versa). A review of Tables 4.12 and 4.13 will show the same results.

Table 4.12: Contingency Table for Clause No. 1.5 as a Lump Sum Project

Clause Title: Preliminary Network Submission Deadline		*Clause Desirability Rating* **Yes**	**Und/No**	**Totals**
Project Complexity Rating	**High**	15 (8.7)	0 (6.2)	15
	Medium	7 (8.1)	7 (5.9)	14
	Low	3 (8.1)	11 (5.9)	14
	Totals	25	18	43
	χ^2	18.93		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.664		

Table 4.13: Contingency Table for Clause No. 3.7.2 as a Lump Sum Project

Clause Title: Change Order Summary/Documentation		*Clause Desirability Rating* **Yes**	**Und/No**	**Totals**
Project Complexity Rating	**High**	14 (9.4)	1 (5.6)	15
	Medium	9 (8.8)	5 (5.2)	14
	Low	4 (8.8)	10 (5.2)	14
	Totals	27	16	43
	χ^2	13.02		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.550		

Tables 4.14 through 4.16 are Contingency Tables for the Lump Sum project clauses with the three lowest Cramer's *V* statistic in which the f_e criteria

was met. The same conditions for accepting/rejecting H_o and H_a previously stated above still apply.

Table 4.14: Contingency Table for Clause No. 2.3.5 as a Lump Sum Project

Clause Title: Activity Level Resources		*Clause Desirability Rating* **Yes**	**Und/No**	**Totals**
Project Complexity Rating	**High**	9 (7.3)	6 (7.6)	15
	Medium	8 (6.8)	6 (7.2)	14
	Low	4 (6.8)	10 (7.2)	14
	Totals	21	22	43
	χ^2	3.44		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.283		

A review of Table 4.14 shows that the condition to accept H_o and reject H_a is met. Therefore, for Lump Sum notional projects, the relationship of clause desirability and project complexity for clause *"2.3.5 Activity Level Resources"* is not statistically significant. Does this mean that there is no relationship between clause desirability and project complexity for this clause? No, it only means that there is not enough evidence to reject H_o at a confidence level of $\alpha = 0.05$. Also, since χ^2 increases as the number of f_o increases, additional respondents would likely result in χ^2 exceeding the critical value of χ^2. For example, if all of the f_o in

Table 4.14 were doubled, then χ^2 would equal 6.87. This value is high enough to reject H_o and accept H_a. However, it is interesting to note that Cramer's *V* would remain the same. This happens because the total number of observed frequencies does not affect Cramer's *V* statistic.

A review of Tables 4.15 and 4.16 also show that there is not enough evidence to reject H_o.

Table 4.15: Contingency Table for Clause No. 2.3.7 as a Lump Sum Project

Clause Title: Activity Costs		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	10 (8.7)	5 (6.2)	15
	Medium	9 (8.1)	5 (5.9)	14
	Low	6 (8.1)	8 (5.9)	14
	Totals	25	18	43
	χ^2_2	2.01		
	χ^2 critical	5.99		
	Cramer's *V*	0.216		

Table 4.16: Contingency Table for Clause No. 3.3 as a Lump Sum Project

Clause Title: Updated Network Approval		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (9.0)	4 (5.9)	15
	Medium	9 (8.5)	5 (5.5)	14
	Low	5 (8.5)	8 (5.5)	14
	Totals	26	17	43
	χ^2	2.94		
	χ^2 critical	5.99		
	Cramer's *V*	0.261		

Fifty-three percent of the clauses for notional Lump Sum projects did not meet the criteria for *fe*. However, Contingency Tables were constructed for these clauses, and χ^2 and Cramer's *V* statistic were calculated for each clause. While the calculated χ^2 value cannot be used to accept/reject H_o and H_a for these clauses, Cramer's *V* statistic can be used to provide insight on the strength of the relationship between complexity and clause desirability.

An issue that is of note is that a low *fe* will result in an abnormally high χ^2 value for a corresponding small difference between f_e and f_o. This increases the probability of Type I error, which is rejecting H_o when it is true. However, it does not increase the probability of Type II error, which is failing to reject H_o when it is false. Therefore, for Contingency Tables that do not meet the *fe* criteria, if the resulting χ^2 value is very low, this may show evidence that H_o should be accepted.

Table 4.17 shows the χ^2 and Cramer's *V* statistic results for all clauses regardless of whether the *fe* criteria was met.

Table 4.17: χ^2 Values and Cramer's *V* Statistic for Lump Sum Projects

Clause No.	χ^2	*V*	**Meets f_e Criteria**	**Clause No.**	χ^2	*V*	**Meets f_e Criteria**
1.1	6.23	0.381	Yes	2.4.2	4.20	0.313	No
1.2	2.61	0.246	No	2.4.3	7.03	0.404	Yes
1.3	19.17	0.668	Yes	2.4.4	4.63	0.328	Yes
1.4	16.02	0.610	No	2.5.1	10.68	0.498	Yes
1.5	18.93	0.664	Yes	2.5.2	6.04	0.375	Yes
1.6	8.77	0.452	No	2.5.3	9.60	0.473	No
1.7	5.99	0.373	Yes	2.6	5.66	0.363	No
1.8	0.99	0.152	No	2.7	6.49	0.388	Yes
1.9	0.51	0.109	No	2.8	18.28	0.652	No
1.10	10.96	0.505	Yes	2.9	7.82	0.426	Yes
1.11	10.35	0.491	No	2.10	10.70	0.517	Yes
1.12	7.40	0.415	No	2.11.1	10.56	0.496	No
1.13	0.73	0.130	No	2.11.2	9.22	0.463	No
1.14	0.11	0.049	No	2.11.3	10.56	0.496	No
2.1	9.60	0.473	No	3.1	11.49	0.517	No
2.2	4.29	0.316	No	3.2	4.30	0.316	Yes
2.3.1	7.33	0.413	No	3.3	2.94	0.261	Yes
2.3.2	6.84	0.399	No	3.4	4.53	0.325	Yes
2.3.3	14.18	0.574	No	3.5	4.17	0.311	Yes
2.3.4	8.77	0.452	No	3.6	6.07	0.376	Yes
2.3.5	3.44	0.283	Yes	3.7.1	8.77	0.452	No
2.3.6	5.63	0.362	No	3.7.2	13.02	0.550	Yes
2.3.7	2.01	0.216	Yes	3.7.3	5.84	0.369	Yes
2.3.8	10.59	0.502	No	3.8	6.04	0.375	Yes
2.4.1	11.71	0.522	Yes				

There is a relationship between project complexity and clause desirability for most clauses; however, there are some clauses that show very little evidence that a relationship exists. The following clauses all have χ^2 value less than three:

- *1.2: Scheduling Responsibility*
- *1.8: Cost of Planning/Scheduling and Monitoring*
- *1.9: Progress Payments for Planning/Scheduling and Monitoring*
- *1.13: Confidentiality/Schedule Ownership*
- *1.14: Computer Access and Security*
- *2.3.7: Activity Costs*
- *3.3: Updated Network Approval*

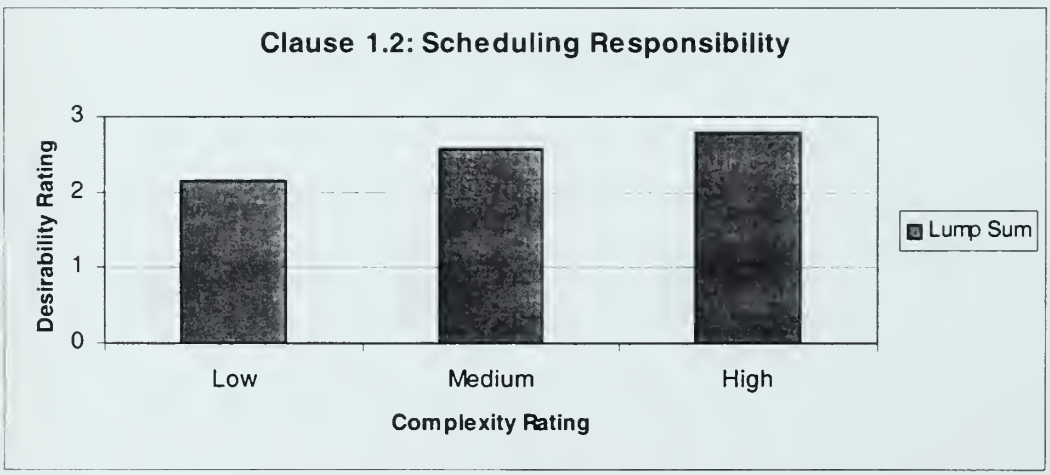

Figure 4.1: Responses to Clause 1.2

Figure 4.1 reveals why clause 1.2 has a very low χ^2 value. This is because this clause's desirability rating is high even for low complexity projects. This clause identifies who is responsible for the *Schedule*.

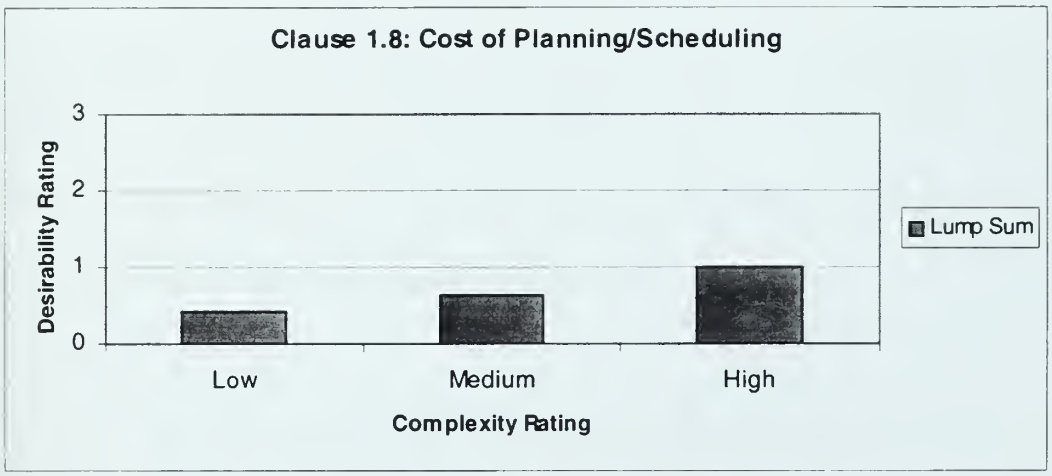

Figure 4.2: Responses to Clause 1.8

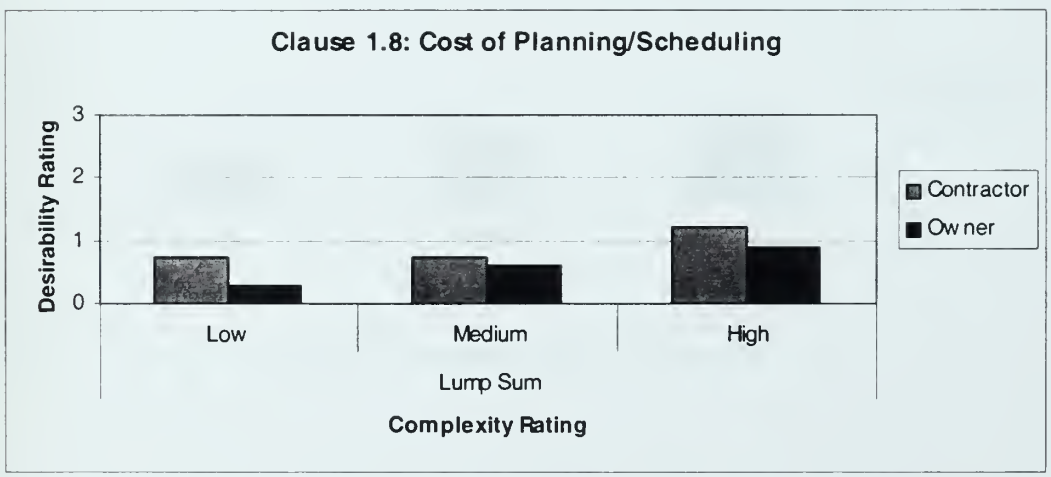

Figure 4.3: Contractor and Owner Responses to Clause 1.8

Figure 4.2 shows that clause 1.8 is not a particularly desirable clause. Figure 4.3 shows how both Contractors and Owners view this clause. Contractors gave it a higher CD rating than Owners. Clause 1.8 sets up the method to estimate how much the Contractor will get paid for performing Planning, Scheduling, and Monitoring.

Clause 1.9, which is shown in Figures 4.4 and 4.5, is dependent upon clause 1.8. Clause 1.9 sets up how progress payments will be made to the Contractor for performing Planning, Scheduling, and Monitoring, which is based on the estimates developed as a result of clause 1.8.

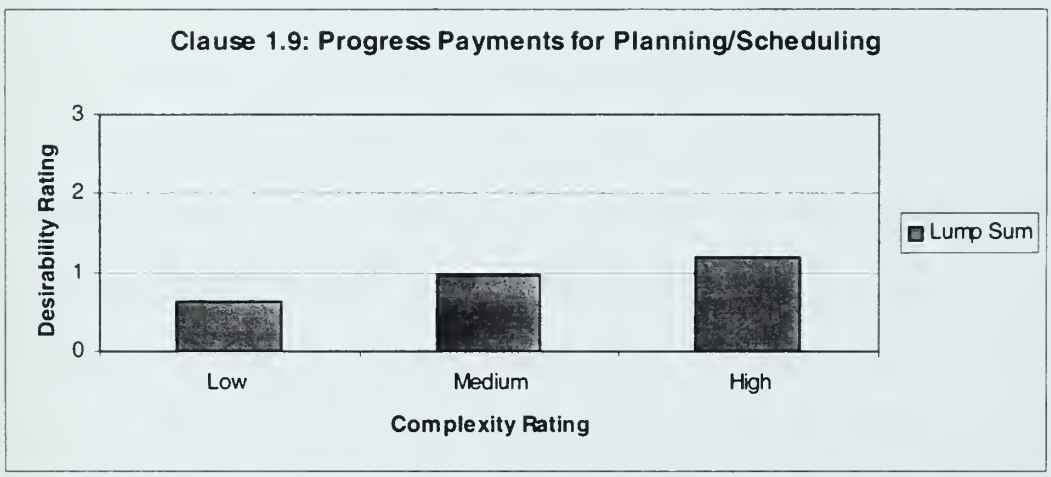

Figure 4.4: Responses to Clause 1.9

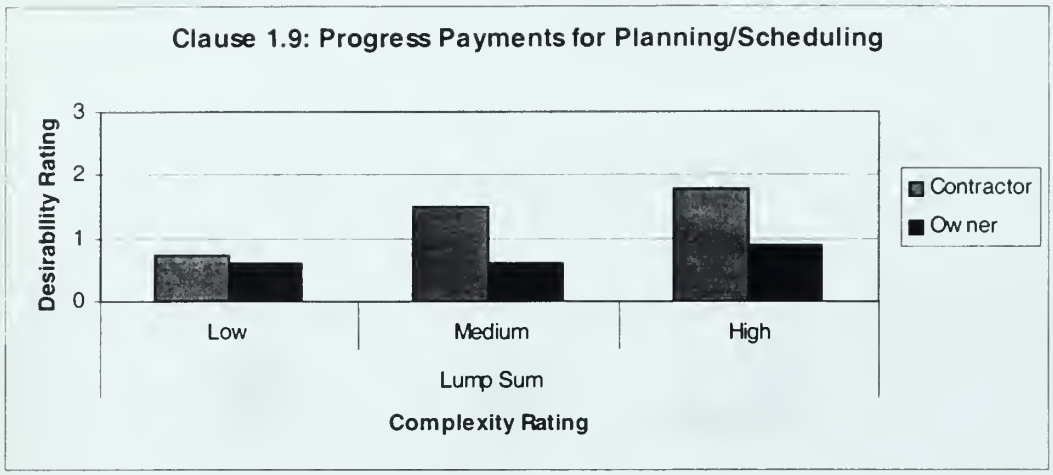

Figure 4.5: Contractor and Owner Responses to Clause 1.9

Figure 4.5 shows a more significant difference between Contractor and Owner Desirability Rating for clause 1.9 than Figure 4.3 did for clause 1.8. This is because clause 1.9 deals with actual progress payments to the Contractor.

The subject of clauses 1.13 and 1.14 is schedule confidentiality and computer access/security. There is a low correlation between complexity and clause desirability for these clauses because the complexity of a project is not related to the need for schedule confidentiality and computer access/security. These are issues are determined by the owner and are independent of project complexity.

There was significant difference in the responses to clause 1.14 between Contractors and Owners (see Figure 4.6). Most of the Owners that responded to the survey are from NAVFAC. The Navy, like other Department of Defense

organizations, is very conscientious regarding computer access and security.

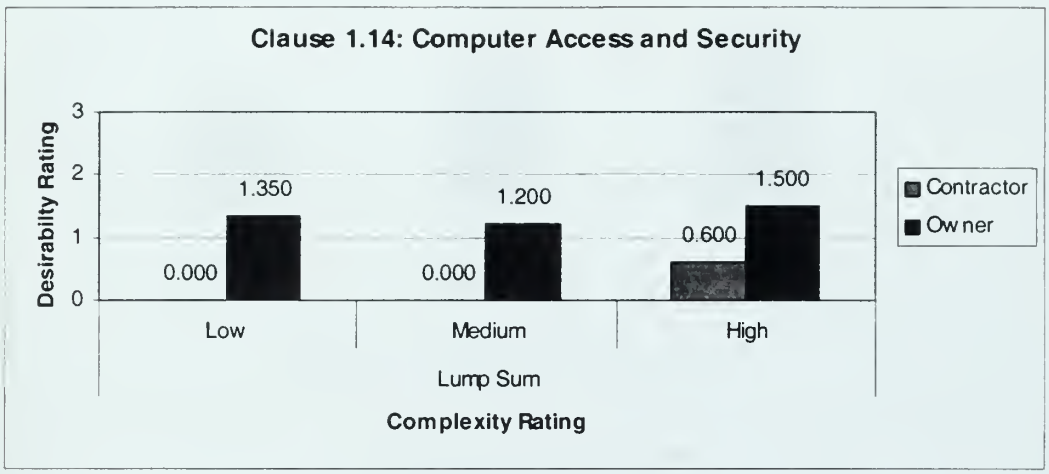

Figure 4.6: Contractor and Owner Responses to Clause 1.14

A review of Figure 4.7 shows that clause 2.3.7 has very little variation in Clause Desirability rating from high complexity to low complexity. Figure 4.8 shows a huge difference in how Owners and Contractors view this clause.

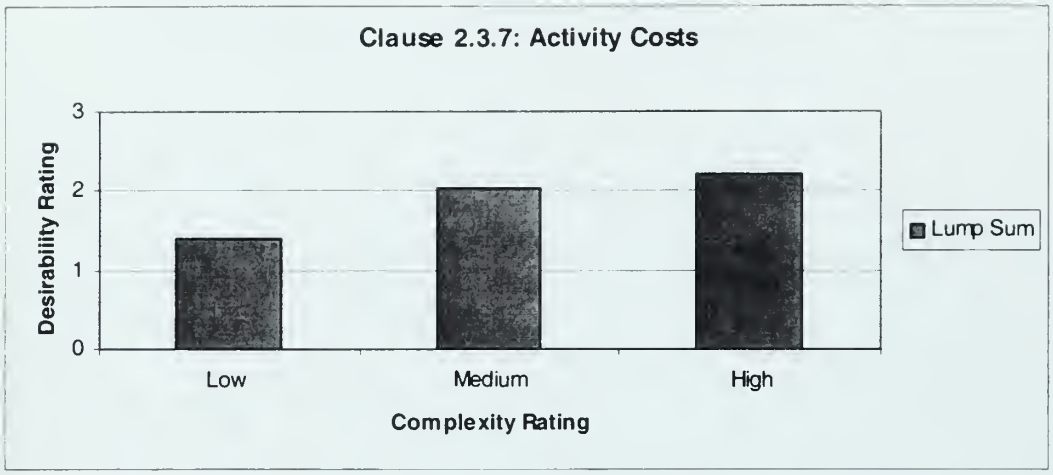

Figure 4.7: Responses to Clause 2.3.7

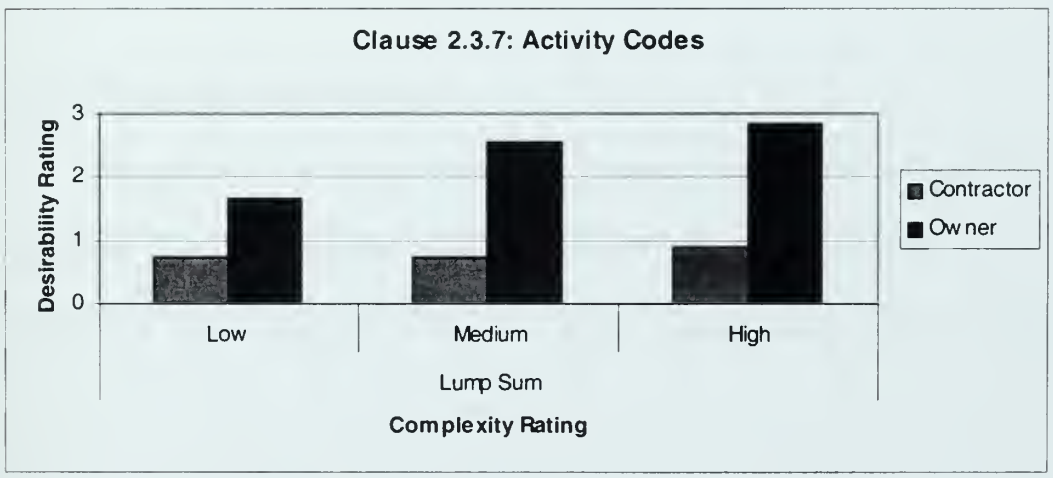

Figure 4.8: Contractor and Owner Responses to Clause 2.3.7

Figure 4.9 also shows very little variance in Clause Desirability rating for clause 3.3 from high complexity to low complexity.

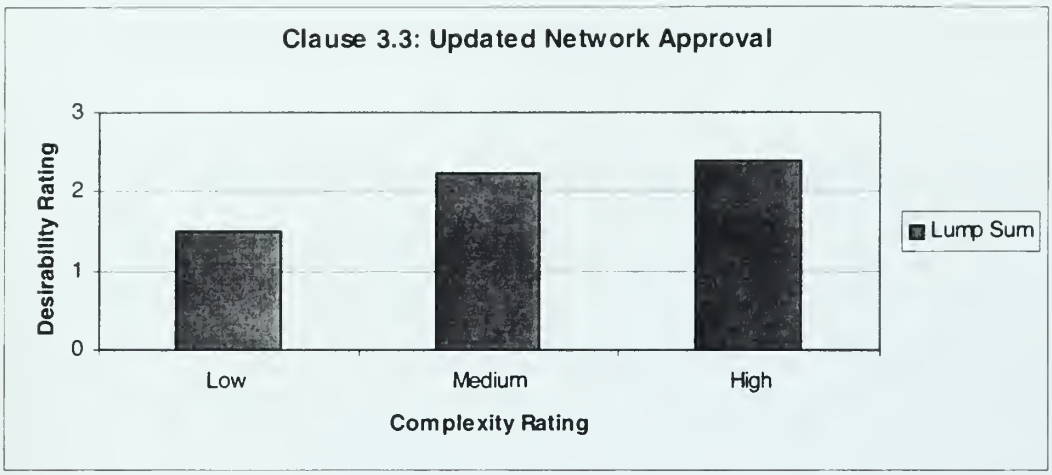

Figure 4.9: Responses to Clause 3.3

4.3.2 Cost Reimbursable Projects

The same χ^2 test of association and Cramer's V statistic were completed for notional Cost Reimbursable projects as were for notional Lump Sum projects. The same α, df, H_o, and H_a were also used. The results of these testes are shown in Table 4.18. If the f_e criteria is met and $\chi^2 \geq 5.99$, then it is concluded that a statistically significant relationship exists between Project Complexity and Clause Desirability. Contingency Tables for all of the clauses that met the f_e criteria are in Appendix J.

Fifty-five percent of the clauses for notional Cost Reimbursable projects did not meet the criteria for f_e. While the calculated χ^2 value cannot be used to accept/reject Ho and Ha for these clauses, Cramer's V statistic can be used to

provide insight on the strength of the relationship between complexity and clause desirability.

Table 4.18 shows the χ^2 and Cramer's V statistic results for all clauses, including those that did not meet the criteria for f_e.

Table 4.18: χ^2 Values and Cramer's *V* Statistic for Cost Reimbursable Projects

Clause No.	χ^2	*V*	Meets f_e Criteria	Clause No.	χ^2	*V*	Meets f_e Criteria
1.1	3.27	0.276	No	2.4.2	5.75	0.379	No
1.2	3.76	0.307	No	2.4.3	7.25	0.426	Yes
1.3	17.88	0.669	Yes	2.4.4	4.81	0.347	Yes
1.4	12.69	0.563	No	2.5.1	10.95	0.523	Yes
1.5	14.40	0.600	No	2.5.2	6.43	0.401	No
1.6	9.12	0.477	No	2.5.3	9.94	0.498	No
1.7	10.92	0.522	Yes	2.6	5.81	0.381	No
1.8	2.74	0.262	No	2.7	6.95	0.417	Yes
1.9	1.23	0.175	No	2.8	12.62	0.562	No
1.10	17.88	0.669	Yes	2.9	6.33	0.398	Yes
1.11	9.69	0.492	No	2.10	9.05	0.494	Yes
1.12	5.47	0.370	No	2.11.1	9.86	0.496	No
1.13	0.73	0.135	No	2.11.2	9.69	0.492	No
1.14	0.73	0.135	No	2.11.3	9.86	0.496	No
2.1	11.42	0.534	No	3.1	8.24	0.454	No
2.2	5.51	0.371	No	3.2	9.13	0.478	No
2.3.1	5.51	0.371	No	3.3	3.26	0.285	Yes
2.3.2	5.01	0.354	No	3.4	7.52	0.433	No
2.3.3	11.77	0.542	No	3.5	6.49	0.403	Yes
2.3.4	9.94	0.498	No	3.6	6.43	0.401	No
2.3.5	4.90	0.350	Yes	3.7.1	7.01	0.419	No
2.3.6	7.54	0.434	No	3.7.2	14.30	0.598	No
2.3.7	3.27	0.286	No	3.7.3	6.58	0.405	Yes
2.3.8	7.09	0.426	No	3.8	8.83	0.470	Yes
2.4.1	9.58	0.489	Yes				

As with the notional Lump Sum projects, there is a relationship between project complexity and clause desirability for most clauses, however; there are some clauses that show very little evidence that a relationship exists. The

following clauses had χ^2 values less than three (none of the clauses met the f_e criteria):

- *1.8: Cost of Planning/Scheduling and Monitoring*
- *1.9: Progress Payments for Planning/Scheduling and Monitoring*
- *1.13: Confidentiality/Schedule Ownership*
- *1.14: Computer Access and Security*

Section 4.2 established that there was not a significant difference between the Specification Desirability (SD) ratings for Lump Sum and Cost Reimbursable projects; therefore, it is expected that the clauses with the four lowest χ^2 value and Cramer's *V* statistic for Lump Sum and Cost Reimbursable projects would match (or at least have some clauses in common). As seen above, the four lowest for Cost Reimbursable projects are the same as the four lowest for Lump Sum projects. Figure 4.6 shows some differences in both Lump Sum vs. Cost Reimbursable and Contractor vs. Owner for clause 1.8.

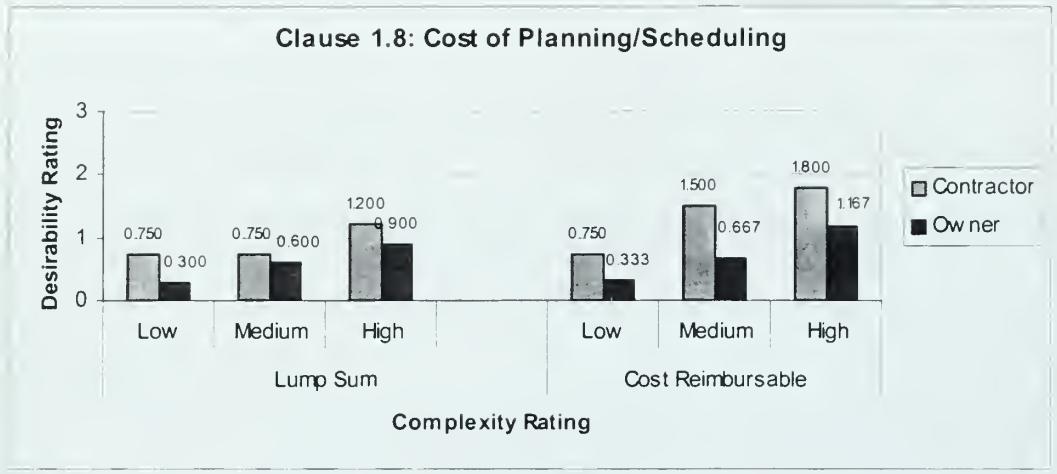

Figure 4.10: Contractor and Owner Responses

A review of Figure 4.10 shows significant difference between Contractor and Owner responses for Cost Reimbursable projects at the medium and high complexity level as compared to Lump Sum projects at the same complexity levels. Even though the Owner assumes more risk with Cost Reimbursable contracts, the Contractor has to spend more administrative time tracking costs. Contractors are probably looking for additional compensation by responding *"Yes"* more often with this clause for Cost Reimbursable projects. If this clause is added to the specification, Planning and Scheduling now becomes a cost that can be adjusted to reflect actual costs instead of part of a set "fee."

4.4 Clause Selection Factor: Contractor vs. Owner

This section evaluates if there is a statistically significant difference in the Specification Desirability (SD) rating between Contractors and Owners for both

Lump Sum and Cost Reimbursable projects. ANOVA was used to determine if the difference between the means is statistically significant. The three assumptions associated with ANOVA (normal distribution, equal variances, and random/independent samples) had to be tested for Contractor and Owner data for both Lump Sum and Cost Reimbursable projects.

4.4.1 Lump Sum Projects

As stated in earlier sections, the samples are random and independent. The χ^2 goodness-of-fit test was performed to see if there was a significant difference between the sample distributions and normal population distribution, and a two-sample F-test to compare two population variations was completed to test the assumption of equal variance. Table 4.19 lists the sample distributions and means for SD ratings of Contractors and Owners for Lump Sum projects.

At first glance, Table 4.19 seems to show a significant difference between Contractor and Owner SD ratings for medium and low complexity projects. ANOVA was used to determine if these differences are statistically significant.

Table 4.19: Specification Desirability Rating for Lump Sum Projects

Contractors			Owners		
High	**Medium**	**Low**	**High**	**Medium**	**Low**
1.898	0.612	0.367	2.602	2.296	1.561
2.204	1.469	0.857	2.296	1.684	1.561
2.813	2.438	0.938	2.082	1.898	1.776
2.344	1.286	0.000	2.602	2.173	1.653
1.898			1.286	1.286	0.704
			2.418	2.051	1.408
			2.602	2.327	1.653
			2.571	1.898	0.000
			2.204	1.776	1.469
			3.000	1.561	0.306
2.231*	1.451*	0.541*	2.366*	1.895*	1.209*

* Sample Mean

As stated above, the χ^2 goodness-of-fit test was used to test the assumption of normal population distribution. The test was performed in the same manner as in Section 4.1. A summary of the results of this test is shown in Table 4.20. All samples met the assumption of normal population distribution.

Table 4.20: Summary of Chi-Square Goodness-of-Fit-Test

Respondent	Project Complexity	χ^2	Critical χ^2	Normal Distribution?
Contractors	High	2.319	9.236	Yes
	Medium	1.134	9.236	Yes
	Low	1.492	9.236	Yes
Owners	High	5.323	9.236	Yes
	Medium	1.721	9.236	Yes
	Low	7.567	9.236	Yes

The two-sample F-test to compare two population variations was completed to test the assumption of equal variance. This test was performed in the same manner as in Section 4.2. H_o and H_a are stated below:

H_o: the population variances are equal.

H_a: the population variances are not equal.

A summary of the results of this test is shown in Table 4.21. The F-test shows that the variances between Contractor and Owner responses for medium complexity projects are not equal. Therefore, ANOVA was not performed for medium complexity Lump Sum projects to see if there was a statistically significant difference in the means.

Table 4.21: Summary of Two Sample F-Test for Population Variation

Project Complexity	Respondent	Variance	F	F_{crit}	P(F≤f)	Reject H_o?
High	Contractor Owner	0.143 0.210	0.682	0.167	0.378	No
Medium	Contractor Owner	0.568 0.110	5.162	3.863	0.024	Yes
Low	Contractor Owner	0.095 0.400	0.238	0.052	0.207	No

H_o and H_a for the ANOVA are stated below:

H_o: the means of the SD ratings for Contractors and Owners are equal for projects with the same Complexity Rating.

H_a: the means of the SD ratings for Contractors and Owners are not equal for projects with the same Complexity Rating.

The same conditions from Sections 4.1 and 4.2 for rejecting/accepting H_o and H_a apply to this case. Table 4.22 is a summary of the ANOVA for all complexities.

Table 4.22: Summary of ANOVA for Lump Sum Projects

Complexity	F	P-value	F_{crit}	Reject H_o?
High	0.321	0.581	4.667	No
Medium	N/A	N/A	N/A	N/A
Low	3.665	0.080	4.747	No

For High and Low Complexity Lump Sum projects, there is not a statistically significant difference between the means for the SD ratings for Contractors and Owners. In other words, Contractors and Owners view P&S specification clauses the same as a whole. However, there are some differences in how Contractors and Owners view specific clauses, and that is investigated in a later section.

4.4.2 Cost Reimbursable Projects

Table 4.23 lists the sample distributions and means for the SD ratings of Contractors and Owners for Cost Reimbursable projects. As with Table 4.19, Table 4.23 seems to show a significant difference between Contractor and Owner SD ratings for medium and low complexity projects. ANOVA was used to determine if these differences are statistically significant.

Table 4.23: Specification Desirability Rating for Cost Reimbursable Projects

Contractors			Owners		
High	**Medium**	**Low**	**High**	**Medium**	**Low**
2.449	1.102	0.367	2.663	2.357	1.622
2.388	1.592	0.857	2.296	1.684	1.561
2.625	1.781	0.781	2.602	2.173	1.653
2.375	1.286	0.000	1.286	1.286	1.224
1.898			2.418	2.051	1.408
			2.602	2.143	1.653
			2.939	2.327	0.000
			2.204	1.776	1.469
			3.000	1.561	0.245
2.347*	1.440*	0.501*	2.446*	1.929*	1.204*

* Sample Mean

Tables 4.24 and 4.25 are summaries of the χ^2 goodness-of-fit test and the two-sample F-tests to compare population variations.

Table 4.24: Summary of Chi-Square Goodness-of-Fit-Test

Respondent	**Project Complexity**	χ^2	**Critical χ^2**	**Normal Distribution?**
Contractors	High	2.274	9.236	Yes
	Medium	1.134	9.236	Yes
	Low	1.492	9.236	Yes
Owners	High	5.101	9.236	Yes
	Medium	1.750	9.236	Yes
	Low	10.199	9.236	No

Table 4.25: Summary of Two Sample F-Test for Population Variation

Project Complexity	Respondent	Variance	F	F_{crit}	P(F≤f)	Reject H_o?
High	Contractor Owner	0.073 0.259	0.281	0.166	0.118	No
Medium	Contractor Owner	0.093 0.137	0.676	0.113	0.409	No
Low	Contractor Owner	0.158 0.399	0.397	0.113	0.241	No

As seen in Table 4.24, the Owners' responses for low complexity projects do not meet the assumption of normal population distribution; therefore, ANOVA was not completed for low complexity projects. Table 4.25 shows that the assumption of equal variances is met (i.e. H_o is accepted).

H_o and H_a for the ANOVA are stated below:

> *H_o: the means of the SD ratings for Contractors and Owners are equal for projects with the same Complexity Rating.*
>
> *H_a: the means of the SD ratings for Contractors and Owners are not equal for projects with the same Complexity Rating.*

The same conditions from Sections 4.1 and 4.2 for rejecting/accepting H_o and H_a apply to this case. Table 4.26 is a summary of the ANOVA for all complexities.

Table 4.26: Summary of ANOVA for Cost Reimbursable Projects

Complexity	F	P-value	F_{crit}	Reject H_0?
High	0.159	0.697	4.747	No
Medium	5.295	0.042	4.844	Yes
Low	N/A	N/A	N/A	N/A

For High Complexity Cost Reimbursable projects, there is not a significant difference between the means for SD rating for Contractors and Owners; however, there is a significant difference for Medium Complexity projects. This happens because as the complexity of the notional project becomes lower, the cost to benefit ratio of P&S specification clauses gets higher (i.e. cost outweighs benefit). Contractors are more likely to want to remove clauses from the specification than Owners.

4.5 Clause Categories based on Differences Between Owners and Contractors

Each P&S specification clause is placed into one of nine different categories. The categories are based on average Clause Desirability (CD) ratings for Contractor respondents and average Clause Desirability (CD) ratings for Owner respondents. The average CD rating for each clause was calculated as follows:

$$Average\ CDr_i = \frac{HCDr_i + MCDr_i + LCDr_i}{3}$$

where

$Average\ CDr_i$ = Average Clause Desirability rating for clause i

$HCDr_i$ = Clause Desirability rating for clause i for projects with a high complexity rating

$MCDr_i$ = Clause Desirability rating for clause i for projects with a medium complexity rating

$LCDr_i$ = Clause Desirability rating for clause i for projects with a low complexity rating

Table 4.27 defines the requirements for each category. None of the clauses met the requirements for Category VI.

Table 4.27: Clause Category Definitions

Category	Owner CD rating (CDr) Requirement	Contractor CD rating (CDr) Requirment
I	CDr ≥ 2.0	CDr ≥ 2.0
II	CDr ≥ 2.0	2.0 > CDr ≥ 1.0
III	2.0 > CDr ≥ 1.0	CDr ≥ 2.0
IV	2.0 > CDr ≥ 1.0	2.0 > CDr ≥ 1.0
V	CDr ≥ 2.0	1.0 > CDr
VI	1.0 > CDr	CDr ≥ 2.0
VII	2.0 > CDr ≥ 1.0	1.0 > CDr
VIII	1.0 > CDr	2.0 > CDr ≥ 1.0
IX	1.0 > CDr	1.0 > CDr

4.5.1 Category I Clauses

The clauses in Category I (Table 4.28) are clauses that both Owners and Contractors favor including in specifications (i.e. the average CDr $\geq$ 2.0). A review of Table 4.28 shows that most Category I clauses for Lump Sum projects are also in Category I for Cost Reimbursable projects. This was found to be true in most other Categories.

Table 4.28: Category I Clauses

Lump Sum Projects		Cost Reimbursable Projects	
1.2	Scheduling Responsibility	1.2	Scheduling Responsibility
1.6	Detailed Network Submission	1.6	Detailed Network Submission
2.1	Network Analysis Technique	2.1	Network Analysis Technique
2.2	CPM Software (or equal) to be Used	2.2	CPM Software (or equal) to be Used
2.3.1	Activity Description	2.3.1	Activity Description
2.3.2	Activity Duration (Time Units)	2.3.2	Activity Duration (Time Units)
2.3.3	Activity Coding System	2.3.3	Activity Coding System
		2.3.4	Responsibility Codes
2.3.8	Work Calendars	2.3.8	Work Calendars
2.5.3	Detailed Network	2.5.3	Detailed Network
3.1	Updating Frequency		

Category I clauses are concerned with the basic requirements needed for a good planning and scheduling system. These clauses establish the following: who is responsible for the scheduling, submission deadlines, software to be used,

network analysis technique, calendars, updating frequency, activity coding systems, et cetera. The information contained in Category I clauses is essential to a well-run project.

Clause 1.2 establishes whether the Owner's representative or the Contractor is responsible for scheduling. Clauses 1.6 and 3.1 are concerned with submission deadlines and updating frequencies. Clauses 2.1 and 2.2 establish the network analysis technique to be used and the CPM software to be used.

The focus of clauses 2.3.1, 2.3.2, 2.3.3, 2.3.4 and 2.3.8 is communication between Owners and Contractors. Both parties need to know how the schedule is read and organized.

4.5.2 Category II Clauses

The clauses in Category II (Table 4.29) are clauses that Owners favor including in specifications, but Contractors are undecided about including these clauses in specifications. As seen with Category I clauses, there are few differences between Lump Sum projects and Cost Reimbursable projects.

Table 4.29: Category II Clauses

Lump Sum Projects		Cost Reimbursable Projects	
1.1	Description, References, Standards	1.1	Description, References, Standards
		1.5	Preliminary Network Submission
2.3.4	Responsibility Codes		
		2.3.7	Activity Costs
2.8	Activity Sorting Requirements	2.8	Activity Sorting Requirements
		3.1	Updating Frequency
3.2	Updating Participation	3.2	Updating Participation
3.3	Updated Network Approval	3.3	Updated Network Approval
3.4	Updating Turnover Time	3.4	Updating Turnover Time
3.7.1	Change Order Representation	3.7.1	Change Order Representation
3.7.2	Change Order Summ./Documentation	3.7.2	Change Order Summ./Documentation
3.7.3	Timing of Change Order Incorporation	3.7.3	Timing of Change Order Incorporation
3.8	Required Reports at Each Update		

A review of Category II clauses reveals that many of them require action by the Contractor so that the Owner will have a better feel for the status of the project. The subject of clauses 3.7.1, 3.7.2, and 3.7.3 is *Change Orders.* These clauses give specific requirements to the Contractor so that the Owner can track how *Change Orders* are affecting the project. Clause 3.2 could require the Contractor to involve subcontractors in update meetings.

4.5.3 Category III Clauses

The clauses in Category III (Table 4.30) are clauses that Contractors favor including in specifications, but Owners are undecided about including these clauses in specifications. A review of Table 4.30 shows that Category II clauses are exactly the same for both Lump Sum and Cost Reimbursable projects.

Table 4.30: Category III Clauses

Lump Sum Projects		Cost Reimbursable Projects	
2.4.1	Maximum Activity Duration	2.4.1	Maximum Activity Duration
2.5.1	Summary Schedule	2.5.1	Summary Schedule
2.5.2	Preliminary Network	2.5.2	Preliminary Network
2.7	Milestones and Imposed Dates	2.7	Milestones and Imposed Dates
3.6	Float Management	3.6	Float Management

It is surprising that Clause 2.4.1 is in this category. This clause is an effort to influence the level of detail of the construction schedule. More detailed project scheduling requirements are designed to result in better planning and coordination than less detailed requirements (Zack 1992). Greater scheduling detail requires more effort and time from the Contractor; however, it ultimately benefits both the Owner and Contractor. It very well could be expected for this clause to be in Category II or Category I because the Owner benefits from it without requiring additional effort.

The other clauses in this Category are of the informational type and are viewed as being more important to Contractors than to Owners.

4.5.4 Category IV Clauses

The clauses in Category IV (Table 4.31) are clauses that both Owners and Contractors are undecided about including in specifications. For most of the clauses in this Category, there is a strong relationship between clause desirability and project complexity. For Lump Sum projects, this relationship is proven true for clauses 1.3, 1.5, 1.7, 1.10, and 2.4.3 in Section 4.3 (see Table 4.17). Also, for

Cost Reimbursable projects, this relationship is proven true for clauses 1.3, 1.7, 1.10, 2.4.3, 3.5, and 3.8 in Section 4.3 (see Table 4.18).

Table 4.31: Category IV Clauses

Lump Sum Projects		Cost Reimbursable Projects	
1.3	Min. Quals. of P&S Staff	1.3	Min. Quals. of P&S Staff
1.5	Preliminary Network Submission		
1.7	Review and Approval Process	1.7	Review and Approval Process
1.10	Subcontractor Input	1.10	Subcontractor Input
1.11	Contractor's Scheduling Plan		
2.3.6	Project Level Resources	2.3.6	Project Level Resources
2.4.3	Min. No. Acts. in Completed Network	2.4.3	Min. No. Acts. in Completed Network
2.4.4	Min. No. Acts. in Prelim. Network	2.4.4	Min. No. of Acts in Prelim. Network
2.6	Project Breakdown Structure	2.6	Project Breakdown Structure
3.5	Updating Records and Reporting	3.5	Updating Records and Reporting
		3.8	Required Reports at Each Update

The desirability of these clauses is strongly affected by project complexity. This means for highly complex projects they are seen as beneficial, but for projects of a low complexity, the cost is perceived to outweigh the benefit. Take clause 1.3 for instance, having a highly trained planning and scheduling staff for a small project of low complexity and priority is an instance where cost outweighs benefit. However, a highly trained planning and scheduling staff for a large, extremely complex project is an instance where the benefit definitely exceeds the cost.

4.5.5 Category V Clauses

The clauses in Category V (Table 4.32) are clauses that Owners favor including in specifications; however, Contractors do not favor including these clauses in specifications. This Category represents the clauses with the largest difference in average CD ratings between Owners and Contractors. In other words, Owner like these clauses but Contractors do not.

Table 4.32: Category V Clauses

Lump Sum Projects		Cost Reimbursable Projects	
2.3.5	Activity Level Resources	2.3.5	Activity Level Resources
2.3.7	Activity Costs		
2.9	Drafting Requirements	2.9	Drafting Requirements
2.10	Rqrd. Reps Init. Submtl. Compl. Ntwk	2.10	Reqd Reps Init. Submitl. Compl. Ntwk

Contractors probably do not like these clauses because they require the Contractor to place a lot of detail in the network logic diagram, and considerable time must be spent in keeping the requirements specified by these clauses updated. This substantially increases Contractor overhead costs.

Note that clause 2.3.7 is in Category V for Lump Sum projects, but it is in Category II for Cost Reimbursable projects. This is because in Cost Reimbursable projects, the Contractor has a more vested interest in keeping track of *Activity Costs* and reporting them to the Owner.

4.5.6 Category VI Clauses

The clauses in Category VI are clauses that Owners do not favor including in specifications; however, Contractors favor including these clauses in specifications. No clauses fell into this Category for either Lump Sum or Cost Reimbursable projects. This is because clauses that Owners see no value in are more than likely going to be viewed the same way by Contractors. It is surprising that clause *"1.9 Progress Payments for Planning/Scheduling and Monitoring"* did not fall into this Category. Clause 1.9, however, is in Category VIII, which is closely related to Category VI.

4.5.7 Category VII Clauses

The clauses in Category VII (Table 4.33) are clauses that Owners are undecided about including in specifications, but Contractors do not favor including these clauses in specifications. These clauses represent a moderately large difference in average CD ratings between Owners and Contractors. Category VII clauses are similar to Category V clauses.

Table 4.33: Category VII Clauses

Lump Sum Projects		Cost Reimbursable Projects	
1.4	Trng Rqrmt for Ctr, Subctr, Owner	1.4	Trng Rqrmt for Ctr, Subctr, Owner
		1.11	Contractor's Scheduling Plan
1.12	Plan/Sched and Monitoring Audits	1.12	Plan/Sched and Monitoring Audits
1.14	Computer Access and Security	1.14	Computer Access and Security
2.4.2	Maximum Activity Costs	2.4.2	Maximum Activity Costs
		2.11.1	Resource Aggregation
		2.11.2	Resource Leveling
		2.11.3	Resource Allocation Optimization

It is easy to see why all of the clauses in Table 4.33 fall into Category VII. All of the clauses in this Category require the Contractor to complete actions that are likely to increase overhead.

4.5.8 Category VIII Clauses

The clauses in Category VIII (Table 4.34) are clauses in which Owners do not favor including them in specifications; however, Contractors are undecided about including these clauses in specifications.

Table 4.34: Category VIII Clauses

Lump Sum Projects		Cost Reimbursable Projects	
		1.8	Cost of P/S and Monitoring
1.9	Progress Paymts for P/S & Monitoring	1.9	Progress Paymts for P/S & Monitoring
1.13	Confidentiality/Schedule Ownership	1.13	Confidentiality/Schedule Ownership

It is easy to see why clauses 1.8 and 1.9 are included in this Category. It is foreseeable that these two clauses could be in Category VI. Clause 1.13 is most

likely in this Category because of *Schedule Ownership*. It states that one party (i.e. Owner, Contractor, Consultant) shall exclusively own the schedule. Owners do not like this clause because they do not want the responsibility that comes with "owning" the schedule, but on the other hand, they do not want the Contractor to have "exclusive ownership" of the schedule either.

4.5.9 Category IX Clauses

The clauses in Category IX (Table 4.35) are clauses that neither Owners nor Contractors favor including in specifications. Note that no clauses fell into this Category for Cost Reimbursable Projects.

Table 4.35: Category IX Clauses

Lump Sum Projects		Cost Reimbursable Projects
1.8	Cost of P/S and Monitoring	None
2.11.1	Resource Aggregation	
2.11.2	Resource Leveling	
2.11.3	Resource Allocation Optimization	

It is surprising that clause 1.8 falls into this Category instead of Category VI or VIII. There are a number of reasons why the Resource Aggregation, Leveling, and Allocation Optimization clauses are in this Category. Any of the following may be why they are in this Category:

- Too complicated to implement and enforce
- A maximum of two or three resources can only be optimized at one time
- There is no "perceived shortage" resources that would make these clauses more beneficial
- It reduces the flexibility of the schedule

Chapter 5: Conclusions and Recommendations

This chapter presents conclusions and recommendations based on the research and analysis conducted in the previous chapters.

5.1 Conclusions

The conclusions drawn from this research are summarized in the following statements:

- *Project Complexity is related to the number of Planning and Scheduling Specification Clauses desired by both Owners and Contractors in construction contracts for both Lump Sum and Cost Reimbursable Projects.*
- *The number of Planning and Scheduling Specification Clauses desired by both Owners and Contractors is not related to Contract Remuneration Type.*
- *The Desirability Rating of numerous Planning and Scheduling Clauses is strongly related to Project Complexity.*
- *Owners and Contractors view many Planning and Scheduling Clauses the same and many Clauses differently based on the content of the Clause, Project Complexity, and Contract Remuneration Type.*

5.2 Recommendations

Many experts in the field of Planning and Scheduling have stated that for P&S specifications to be effective, they need to meet the objectives of both Owners and Contractors. Many P&S specification clauses that meet the objectives of one party, do not meet the objectives of the other party. This is why

some clauses that are desired by Owners are not desired by Contractors and vice versa.

Another key factor in a P&S specification system that works well is to specify the appropriate level and amount of P&S specifications for the project to be constructed. The Owner has to determine the benefit to cost ratio for each clause, and he/she must also consider the benefit to cost ratio for the Contractor. If the Contractor realizes an excellent benefit to cost ratio for the P&S specification system, then the system will be a much more effective tool for tracking the status and controlling the project.

Even though projects should always be considered on an individual basis, Table 5.1 was developed to assist in selecting P&S specification clauses. It should be used as a guide only. The matrix should be read as follows:

- ***Y**: include the clause in the contract specifications for corresponding complexity level and remuneration type.*
- ***U**: the clause should be considered for inclusion into the specification for corresponding complexity level and remuneration type.*
- ***N**: the clause probably should not be considered for inclusion into the specification for corresponding complexity level and remuneration type.*

Table 5.1: P&S Specification Clause Selection Matrix

Clause No.	Lump Sum Contracts			Cost Reimbursable Contracts		
	High	Medium	Low	High	Medium	Low
1.1	Y	U	U	Y	Y	U
1.2	Y	Y	Y	Y	Y	Y
1.3	Y	U	N	Y	U	N
1.4	Y	N	N	U	N	N
1.5	Y	U	N	Y	U	N
1.6	Y	Y	U	Y	Y	U
1.7	Y	U	N	Y	U	N
1.8	U	N	N	U	N	N
1.9	U	N	N	U	U	N
1.10	Y	U	N	Y	U	N
1.11	Y	N	N	U	N	N
1.12	U	N	N	U	U	N
1.13	U	N	N	U	U	N
1.14	U	N	N	U	N	N
2.1	Y	Y	U	Y	Y	U
2.2	Y	Y	U	Y	Y	U
2.3.1	Y	Y	U	Y	Y	U
2.3.2	Y	Y	Y	Y	Y	Y
2.3.3	Y	Y	U	Y	Y	U
2.3.4	Y	Y	U	Y	Y	U
2.3.5	Y	U	U	Y	U	N
2.3.6	U	U	N	Y	U	N
2.3.7	Y	Y	U	Y	Y	U
2.3.8	Y	Y	U	Y	Y	U
2.4.1	Y	Y	N	Y	Y	N
2.4.2	U	U	N	U	U	N
2.4.3	U	U	N	Y	U	N
2.4.4	U	U	N	Y	U	N
2.5.1	Y	Y	N	Y	Y	N
2.5.2	Y	U	U	Y	U	U
2.5.3	Y	Y	U	Y	Y	U
2.6	U	U	N	U	U	N
2.7	Y	Y	N	Y	Y	N
2.8	Y	Y	N	Y	Y	N
2.9	Y	U	N	Y	U	N
2.10	Y	U	N	Y	U	N
2.11.1	U	N	N	U	N	N
2.11.2	U	N	N	U	N	N
2.11.3	U	N	N	U	N	N
3.1	Y	Y	U	Y	Y	U
3.2	Y	Y	U	Y	U	U
3.3	Y	Y	U	Y	U	U
3.4	Y	Y	U	Y	U	U
3.5	Y	Y	U	Y	U	U
3.6	Y	Y	U	Y	U	U
3.7.1	Y	Y	U	Y	Y	U
3.7.2	Y	Y	N	Y	U	N
3.7.3	Y	U	U	Y	U	U
3.8	Y	U	U	Y	U	U

Appendix A

Sample Planning and Scheduling Guide Specifications

Editing Notes:

This section will describe how the typical editing symbols describe the editing decisions that are used. This will facilitate the communication of the proposed specification drafter to the editor who will actually be modifying the specification for a particular project. The key to editing the guide specification is to fully understand the intent of the choices and decisions that are presented. The following explanation should be carefully reviewed before beginning to edit the specification:

[option x] will indicate an optional word, number, sentence or paragraph. This symbol indicates that the choice of only one option of many is required. For convenience the brackets will simply enclose the options in most cases when there are one number or word choices. If the options do not suit the editor, there is usually a wide degree of flexibility to include another option of the editor's choosing. The use of the option decision is illustrated in the following example:

> The contractor shall provide a minimum of [10] [20] [40] [80] [ ] hours of classroom instruction to teach a maximum of [5] [10] [ ] owner representatives about the contractor's network development techniques and the selected computer software application.

The editor must choose only one of the bracketed numbers or insert another of their own in lieu of the empty brackets.

> selection x < will indicate a sentence, paragraph or section that can be optionally included as a choice of one or more selections. - It will be a stand alone sentence, paragraph or section so the editor's choice will only involve the selection or omission of the words indicated. This editing decision differs from the option described above in that the editor may choose as many of the selections that may apply to the desired specification. Remember that all specification paragraphs should be renumbered in sequence after final editing. The use of the selection decision is illustrated in the following example:

> The computerized analysis shall be performed with the capabilities of the following sorts with the priorities indicated:
> **> selection 1 <** **Activity listing by number sequence.**
> **< selection 2 <** **Activity sort by total float - early start date**
> **< selection 3 <** **Activity sort by trade -early start date - total float.**
> **> selection 4 <** **Contractor's monthly payment request sorted by [responsibility code] [PBS code] [CSI code]**

In this case the editor may choose any or all of the selections indicated. Selection 1, 2 and 4 may be selected without worrying that the missing selection 3 will impact the specification.

{ alternative x } will indicate an alternative word, sentence, paragraph or entire section - This symbol will be used to tell the specification editor there is a choice of whether or not to include the item indicated. The alternative may or may not be included without affecting the rest of the specification. The use of the alternative decision is illustrated in the following example which includes each of the editing decisions that have been discussed above:

> selection 5 < [2] [3] [5] copies of the cost report sorted by the responsibility code which shall serve as a monthly request for progress payment.
{alternative 1} This report, along with the progress update meeting described above shall provide the basis for the contractor's progress payment request and the contractor shall be entitled to progress payments determined from the approved update. If the contractor fails or refuses to furnish the information and network data which, in the sole judgment of the Owner, is necessary for verifying the Contractor's progress, the contractor shall be deemed not to have provided a progress payment estimate and therefore no progress payments will be made.
{alternative 2} If the schedule updates occur more frequently than one month apart, only one request for payment per month will be permitted.

The editor must only decide if the specification would be enhanced with the alternatives presented. If they are considered inappropriate to the project, then they may be deleted. Otherwise one or both of the alternatives may be included.

*(**A note to the editor**)* will be used to indicate a note to the editor, which is not intended to become part of the final specification. This symbol will be used to provide general comments or explanations to help the editor understand a particular specification section. The entire comment should be deleted before completing the editing process.

The specification editor has been provided space to include his own options, selections and alternatives where appropriate and is strongly encouraged to develop these areas to suit the type of project for which the guide specification is to be used.

To see how the overall editing process would work for each of the editing decisions the following step by step procedure is provided:

1. Remove unwanted text using the editing decisions described above.
2. Delete the editing decision labels (e.g.: [option], > selection < or {alternative})
3. Insure that the text is properly left justified and the line spacing is sequential after deleting text or labels.
4. Renumber specification paragraphs
5. Change text to desired fonts and pitch sizes
6. Insure text is properly adjusted to fit the required document format e.g.: page width, margin size, etc

Your project specification is now ready for incorporation into the bidding documents.

The specification will be presented with the assumption that the editor is reviewing the guide specification required for a project of typical length, cost and complexity for which a substantial degree of control is desired. These factors must be considered when editing the specifications for greater or lesser projects. The proposed specification as written covers the typical project factors and should be scaled up or down for the appropriate application. The editor is strongly encouraged to become familiar with the abilities of the contractors most likely to bid the project before the specification is incorporated into the final contract documents.

Dr. Calin Popescu

SECTION 1 GENERAL ORGANIZATION AND RESPONSIBILITIES

1.1 DESCRIPTION, REFERENCES, STANDARDS

1.1.1 DESCRIPTION: The scope of this specification is to require the use of Critical Path Method Scheduling to assure adequate planning and control during the execution of all work required by this contract. The Schedule is to be used for assuring that all work will be completed by the contract completion date. This specification covers all scheduling, creation of the network, production of reports, execution of the scheduling plan and regular joint review and updating of the schedule. The scope of the scheduling effort shall include *(Pick applicable description or insert your own. The words between the > < indicate the **selections 1-18)*** > design scope definition <, > detailed design <, > design reviews <, > design approval <, > contractor selection <, > land acquisition <, > permitting <, > major material and equipment procurement <, > shop drawing and submittal approval <, > major material and equipment fabrication and delivery <, > site mobilization <, >field erection / installation <, > testing <, > on site inspections <, > off site inspections <, > acceptance <, > commissioning <, > final start-up <, > final acceptance < and all related activities.<
> **selection 19** < The Schedule updating process shall also be used as a basis of estimating and approving progress payments.

1.1.2. REFERENCES For additional material that should be helpful to understand the details of CPM scheduling and this specification the following references are recommended:
> **selection 1** < "CPM in Construction Management " Third Edition, James J. O'Brien McGraw-Hill Book Company, New York, NY, 1984
> **selection 2** < "Project Management with CPM and PERT" Second Edition, Joseph J. Moder, Cecil R. Philips, Van Nostrand Reinhold Company, 1970
> **selection 3** < "Critical Path Methods in Construction Practice" Third Edition, Wiley, 1982 > selection 4 ~ "A Management Guide to PERT / CPM" Second Edition, Jerome J. West; Ferdinand K. Levy, Prentice Hall Inc. 1977
> **selection 5** < "Construction Project Scheduling" First Edition, Michael T. Callahan, et all, McGraw Hill, 1992
> **selection 6** < "Regulation ER 1-1-11, Network Analysis", Department of the Army – Corps of Engineers, Publications Department, Alexandria, VA 22304.
> **selection** < .....

1.1.3 STANDARDS The following standards shall be considered to be incorporated into this specification by reference:
> **selection 1** < "Project Planning, Scheduling and Control Glossary of Terms", C & C Consultants Inc., November 1991
> **selection 2** < "Project Planning, Scheduling and Control Encyclopedia of Terms", C & C Consultants Inc., 1992
> **selection** <

1.2 SCHEDULING RESPONSIBILITY
[option 1] The scheduling of construction is the sole responsibility of the [Contractor] [Owner's Project Manager] and the Contractor's management personnel shall actively participate in the

development of the network logic diagram so that the intended sequences and procedures are clearly understood throughout the [Contractor's] [Project Manager's] scheduling organization.

[option 2] The use of a consultant with the specific qualifications required elsewhere in this specification is allowable however the [Contractor] [Owner's Project Manager] shall retain full responsibility for all project scheduling. The Contractor's management personnel shall actively participate in the development of the network logic diagram so that the intended sequences and procedures are clearly understood and recorded by the consultant.

1.3 MINIMUM QUALIFICATIONS FOR PLANNING AND SCHEDULING STAFF

> selection 1 < All personnel in the scheduling organization must possess adequate scheduling knowledge related to CPM and the project as well as a detailed knowledge of the "specified] [proposed] CPM implementation software.

< selection 2 < All key personnel in the scheduling organization must possess the ability to communicate effectively with others in the field of CPM planning, scheduling and control that are familiar with modern data processing and scheduling techniques and terminology.

> selection 3 < All key personnel in the scheduling organization must possess [an undergraduate engineering degree from an accredited university], [a masters/PhD graduate degree in construction management], [have [30] [60] [80] [120] [160] [ ] course hours of continuing education in project planning and scheduling], and [have [3] [5] [10] [ ] years of on the job experience in scheduling of projects similar in nature to the subject contract.

> selection 4 < There must be an adequate number of scheduling [personnel] [engineers] to handle the responsibilities designated by the Contractor's Scheduling Plan. There must be adequate staff personnel to support the data and information handling required by the Contractor's Scheduling Plan for the project.

> selection <.....

{alternative 1} When the Contractor's scheduling personnel do not meet the minimum qualifications, CPM training as described in section 1.4 may be substituted. *(this option adds a slightly different twist to the training requirements described below and should be used appropriately)*

{alternative }

1.4 CPM TRAINING REQUIREMENTS

> selection 1 < The Contractor shall provide a minimum of [10] [20] [40] [80] [ ] hours of classroom instruction to teach [a maximum of [5] [10] [ ] owner representatives about the contractor's network development techniques and the selected computer software application. <

> selection 2 < The Contractor shall provide [continuous] [a minimum of [20] [40] [80] [ ] hours] education in CPM planning and scheduling methods for [a minimum of [5] [10] [ ]] contractor personnel [during the course of completion] or [before submitting a network diagram for approval.] The Contractor shall submit a training plan consisting of specific instructors with associated qualifications, a course outline and a schedule, which describes the basic course content. The personnel that will participate in the training must be identified in the plan.

> selection 3 < The Contractor shall provide [continuous] [a minimum of [20] [40] [80] [ ] hours] education in CPM planning and scheduling methods for [a minimum of [5] [10] [ ]] subcontractor personnel [during the course of completion] or [before submitting a network diagram for approval.] The Contractor shall submit a training plan consisting of specific instructors with associated qualifications, a course outline and a schedule, which describes the basic course content. The personnel that will participate in the training must be identified in the plan. <

> selection < .....

1.5 PRELIMINARY NETWORK SUBMISSION DEADLINE
Within [20] [30] [ ] days after the notice of contract award the Contractor shall submit for the [Owner's] [Owner's Representative] approval, [3] [ ] copies of the proposed preliminary network defining the contractor's planned operation during the first [45] [60] [90] [ ] days of the contractor's work effort.
{alternative 1} The Contractor will not be allowed access to the construction site until the preliminary network is approved.
{alternative 2} No progress payments will be made until the preliminary network is approved.
{alternative 3} Progress payments will be allowed based on the approved preliminary network [until the detailed network is approved] [for a maximum of [60] [90] [ ] days after the preliminary network is approved.
{alternative }

1.6 DETAILED NETWORK SUBMISSION DEADLINE
Within [45] [60] [90] [ ] days after the notice of contract award the Contractor shall submit for the [Owner's] [Owner's Representative] approval, [2] [3] [ ] copies of the complete network diagram and computerized analysis {using the [selected] [proposed] CPM software}.

1.7 REVIEW AND APPROVAL PROCESS
Within [5] [10] [15] [ ] working days after receipt of the preliminary and/or complete network diagram(s), the Owner's representative will meet with the Contractor for a joint conference type review of the proposed plan and schedule. Within [5] [10] [ ] working days after the joint review, revise the network diagram in accordance with the agreements reached during the joint review meeting and submit [2] [3] [ ] copies of the revised network diagram. The resubmission will be reviewed by the Owner's representative and, if found to be adequate, it will be approved in writing; an approved copy of each network submission will be returned to the Contractor. The network diagram; as approved by the Owner's representative, shall constitute the project schedule until subsequently revised in accordance with the requirements of this specification.

1.8 COST OF PLANNING / SCHEDULING AND MONITORING
[option 1] *(be sure to coordinate this section with the one following to insure no confusion is created in this area)* The Contractor is expected to include a minimum of [$] as a line item in his estimated bid price for planning and scheduling on this project. *(Based on the owners estimate of the CPM development and implementation costs for the project.)*
[option 2] The Owner will be directly responsible for the cost of planning, scheduling and monitoring.
[option 3] The Owner has allocated [$] in the project budget as a separate account for the project planning, scheduling and control required.

1.9 PROGRESS PAYMENTS FOR PLANNING / SCHEDULING AND MONITORING
[option 1] The Contractor's own cost estimate for planning and scheduling shall not be less than the amount indicated in section 1.8 and must be included as line item on each of the Contractor's request for progress payments. The cost of planning and scheduling shall be proportionately divided for the project duration. These portions shall include the preliminary network stage, the completed network development and approval and the updating through the entire course of the project.

[option 2] The Contractor will be paid for costs pertaining to planning, scheduling and monitoring on a cost reimbursable basis at the regularly scheduled invoice periods indicated for construction progress payments. An early completion incentive fee will be paid based on a rate of [2%] [5%] [10%] [ ] of the Contractor's direct planning, scheduling and monitoring cost per [day] [week] [month] that the project is completed before the official completion date.

1.10SUBCONTRACTOR INPUT

[option 1] The following Subcontractors must have primary input into the development of the project schedule and shall have a scheduling representative present at each review, approval or updating meetings in which their subcontracted work could be involved: Earthwork / heavy equipment operators<, >underground utilities<, >paving<, >landscaping<, >concrete<, >masonry <, >iron work<, >structural steel <, >carpentry<, >moisture protection<, >roofing<, >doors and windows<, >glazing<,>building finishes<, >painting<, >flooring<, >specialty items<, >plumbing<,>HVAC<, >mechanical<,>electrical< *(or include your own)*

[option 2] All major Subcontractors must provide and maintain their own schedules as sub networks of the overall project schedule represented by the complete network diagram. Major Subcontractors shall include the following: >earthwork / heavy equipment operators<, >underground utilities<, >paving<, >landscaping<, >concrete<, >masonry <, >iron work<, >structural steel <, >carpentry<, >moisture protection<, >roofing<, >doors and windows<, >glazing<,>building finishes<, >painting<, >flooring<, >specialty items<, >plumbing<, >HVAC<, >mechanical<, >electrical< *(or include your own)*

{alternative 1} The following Subcontractors must have a scheduling representative present at [all] [applicable] review, approval and update meetings: > earthwork / heavy equipment operators <, > underground utilities <, > paving <, > landscaping <, > concrete <, >masonry <, > iron work <, > structural steel <, > carpentry<, > moisture protection<, > roofing <, > doors and windows <, > glazing <,>building finishes <, > painting <, > flooring<, > specialty items <, > plumbing <, > HVAC<, > mechanical <, > electrical < *(or include your own)*.

{alternative 2} Major Subcontractors must provide and maintain sub networks of all activities included within their subcontract scope to be included as part of the detailed network.

{alternative }

1.11CONTRACTOR'S SCHEDULING PLAN

Within [10] [20] [ ] days after the Contractor has received notice of contract award, a plan must be submitted which describes the processes and procedures that the contractor's organization will follow in developing and implementing a planning and scheduling operation for this project. The plan shall describe in detail:

> **selection 1** < The contractor's corporate policies pertaining to planning and scheduling including the incorporation of specific standards to be used by all personnel throughout the course of the project.

> **selection 2** < A method of representing the contractor's scheduling organization which demonstrates differing levels of responsibility and paths of communication between personnel.

> **selection 3** < A formalized procedure for recording updating and logic changes for later review or audit.

> **selection 4** < An organized method of transferring information to various information users with varying needs including an information and document transfer and storage plan.

> **selection 5** < A method to insure that all the required reports can be generated and distributed within [24] [48] [72] [ ] hours after each update.

> **selection 6** < A detailed list of key personnel described by their job function that will attend the review, updating and approval meetings.

> **selection 7** < A method for verifying and validating input into the network analysis.
> **selection** < .....

1.12PLANNING/SCHEDULING AND MONITORING AUDITS
[Every quarter] [Every six months] [{senior} Contractor {executives} and Owner personnel shall perform an audit of the planning and scheduling operation. The audit shall evaluate the performance in the following areas:
> **selection 1** < The network logic is correct and results from the various contracting organizations participating in the project.
> **selection 2** < The duration, resources and cost for each activity are the result of the best available information during the network development / updating.
> **selection 3** < The logic diagram (network) is well organized and updated to facilitate information retrieval and is used for short interval planning, reviews and updates.
> **selection 4** < The effectiveness of the contractor's scheduling plan as it relates to the regular updates.
> **selection 5** < The executive or senior Project management role in the Planning and scheduling operation.
> **selection** < .....

1.13CONFIDENTIALITY / SCHEDULE OWNERSHIP
> **selection 1** < The [Owner] [Contractor] [Project Manager] [Consultant] agrees to keep secret the contents of the network diagram and all the associated data from any public or private access not expressly allowed by the Owner.
> **selection 2** < The [Owner] [Contractor] [Consultant] shall maintain exclusive ownership rights of the network diagram and all the associated data. Unauthorized distribution of this information will be prosecuted to the full extent of the law.
> **selection** < .....

1.14COMPUTER ACCESS AND SECURITY
{alternative 1} The [Contractor] [Consultants] shall be required to maintain a computer system which restricts access to [input] [both input and output data] only to authorized personnel using a coded secret password system.
{alternative 2} The contents of the CPM network and database do not require specific security requirements other than normal precautions within the [Contractor] [Consultant] organization.
{alternative } .....

SECTION 2 SCOPE AND PRODUCTS

2.1 NETWORK ANALYSIS TECHNIQUE
The contractor shall use the [Arrow Diagramming Method] [Precedence Diagramming Method] [PERT] in the development of the schedule network. The network diagram shall show the order and interdependence of all activities and the method by which the work is to be accomplished.

2.2 CPM COMPUTER SOFTWARE TO BE USED
The Contractor shall use the latest version of ["insert preferred software here"], which shall be capable of operating in a [IBM PC-DOS Version [3.0]] or greater environment. All required network analysis submissions and updates shall be submitted on [3 1/2] [5 1/4] inch, high density diskettes. The disk submittal requirement shall be in addition to any and all hard copy submittals

required. Should the Contractor propose to use software other than ["insert preferred software here"] with equivalent capabilities, prior approval by the [owner] [owner's representative] shall be required. [1] {A [ ] complete sets of the program software for the proposed system shall be delivered by the Contractor to the [Owner] [Owner's representative] within [10] [15] [ ] calendar days following approval by the [owner] [owner's representative]. The Contractor shall also provide two complete sets of user documentation with the program software. Submittal requirements for software shall be as specified above for ["insert preferred software here"].

{alternative 1} The diskettes must be 'write protected' to insure there will not be an accidental overwrite.

[option 1] The program diskettes and user documentation shall become the property of the [owner] [owner's representative] and the [owner] [owner's representative] will be granted all rights customarily afforded to a software licensee by the software company.

[option 2] The program diskettes and user documentation will be returned to the [Contractor] [Consultant] at the completion of the contract.

[option] .....

2.3 ACTIVITY RELATED INFORMATION

The network diagram and tabulated mathematical analysis shall include the following information as a minimum for each activity:

2.3.1

> **selection 1** < ACTIVITY DESCRIPTION: A description of the activity not less than [25] [40] [50] [ ] characters.

2.3.2

> **selection 2** < ACTIVITY DURATION (TIME UNITS): Estimated duration of activities by [work days] [weeks] [months] [hours] [shifts] [ ].

2.3.3

> **selection 3** < ACTIVITY CODING SYSTEM: Organized system of coding activities [Project Breakdown Structure] [CSI specification divisions] [owner provided codes] [ ].

2.3.4

> **selection 4** < RESPONSIBILITY CODE: Trade or responsibility code including prime contractor, subcontractors, suppliers, owner, governmental, or other party responsible for the accomplishment of an activity.

2.3.5

> **selection 5** < ACTIVITY RESOURCES: Resources required at the activity level >materials<, >labor<, and >equipment< which are grouped by project phases or the area in which the work will be performed.

{alternative 1} The following resources must be included: >concrete in cubic yards<, >rebar in tons<, >lumber in board feet<, >pipe in lineal feet<, >sheathing in square feet<, >piles in lineal feet<, >overhead cranes in work days<, >labor by trades in [work hours] [man days]<, *(include resources specific to the important construction aspects of the project)* > <.

2.3.6

> **selection 6** < PROJECT OR MULTIPROJECT LEVEL RESOURCES: Resources required at the project level (bulk materials, trade labor and common equipment used by several activities grouped by project phases or area in which the work will be performed.

2.3.7

> **selection 7** < ACTIVITY COSTS: Monetary value of activity to be used for cost control and progress payments broken down into categories for material, labor and equipment.

2.3.8

> **selection 8** < WORK CALENDAR: Activity calendar, if other than the normal work week which is defined as [Monday - Friday] [Monday - Saturday] [ ] from [0730-1600] [0600-1700] [ ].
{alternative 1} The following holidays will be observed: >New Years Day<, >President's Day<, >Martin Luther King Jr's Birthday<, >Memorial Day<, >Independence Day (July 4)<, >Labor Day<, >Veterans Day<, >Thanksgiving <, >Christmas<, > <
{alternative 2} The following nonworking days or periods will be considered for scheduling:[ ] [ ]
{alternative } .....

2.4 REQUIRED LEVEL OF NETWORK DETAIL
2.4.1
> **selection 1** < MAXIMUM ACTIVITY DURATION: The network diagram shall consist of activities limited to [no more than [15] [30] [ ] [work days] [work weeks] [months] [ ] duration].
2.4.2
> **selection 2** < MAXIMUM ACTIVITY COST: The network diagram shall consist of activities limited to [no more than [$5000] [$10,000] [$50,000] [$100,000] [$] direct cost].
2.4.3
> **selection 3** < MINIMUM NUMBER OF ACTIVITIES IN THE TOTAL NETWORK: The detail network diagram shall consist of a minimum of [500] [1000] [ ] activities. Dummies and interdependencies shall not be included in the count to determine the number of activities.
2.4.4
> **selection 4** < MINIMUM NUMBER OF ACTIVITIES IN THE PRELIMINARY NETWORK: The preliminary network diagram shall consist of a minimum of [100] [200] [500] [ ] activities. Dummies and interdependencies shall not be included in the count to determine the number of activities.

(Note that the decision on how many activities that are required for a particular network to show adequate detail for a project varies greatly. It depends on the project complexity, duration, cost and degree of control desired by the owner. Although the guide specification allows the editor to combine the different level of detail specifications, be careful not to make the requirements too complicated. Using all three selections is not advisable. Too much detail could render the schedule useless because it is too cumbersome to manage at the project level.)

2.5 NETWORK DIAGRAM SCOPE
2.5.1 SUMMARY SCHEDULE: After the notice of contract award the contractor shall provide a summary schedule, which shows the contractor's general approach to the work. This schedule should be of the same level of planning detail that was used to develop the contractor's bid price on this project. The summary schedule shall serve as a basis for developing a complete network of more detail that uses the summary activities as hammock activities. This schedule is for information only and as such it is not subject to the approval conditions specified elsewhere in this specification.

2.5.2 PRELIMINARY NETWORK: The proposed preliminary network shall define all of the contractor's planned operations during the first [45] [60] [90] [ ] days of the project execution. The preliminary network diagram shall show the sequence and interdependence of all activities that are expected to begin within the specified time frame. The preliminary network should be developed to serve as a basis for the initial stages of the project.

{alternative 1} The contractor will not be allowed access to the construction site until the preliminary network is approved.
{alternative 2} The cost of the activities expected to be completed before submission and approval of the detailed schedule may be included for progress payment purposes. Payment requests based on the approved preliminary network will not be processed after the required deadline for a complete network has expired.
{alternative } .....

2.5.3 DETAILED NETWORK: The complete network diagram shall show the sequence and interdependence of activities for complete performance of the work specified in this contract. Show the order and interdependence of activities and the sequence in which the work is to be accomplished as planned. The basic concept of a network analysis diagram will be followed to show how the start of a given activity is dependent on the completion of preceding activities and how its completion restricts or restrains the start of following activities.
{alternative 1} *(include this sentence if section 1.1.1 needs further clarification or was not included in it's entirety)* In addition to construction activities, detailed network activities shall include >design scope definition<, >detailed design<, >design reviews<, >design approval<, >contractor selection<, >land acquisition<, >permitting<, >the submittal and approval of materials, samples, and shop drawings<, >the procurement of critical materials and equipment<, >receipt of materials [with estimated procurement costs of major items for which payment of materials will be requested in advance of installation]<, >fabrication of special material and equipment, and their installation and testing<, >site mobilization<, >field erection installation<, >testing<, >off site testing<, >on site inspections<, >off site inspections<, >acceptance<, >commissioning<, >final start-up<, >final acceptance< and all related activities.
{alternative 2} Show activities of the [owner] [ ] that affect progress and contract required dates for completion of all or parts of the work.
{alternative 3} Show activities indicating [owner furnished materials and equipment] utilizing delivery dates provided elsewhere in the contract.
{alternative 4} An activity description may not completely describe the required work in detail yet this does not relieve the contractor from performing all the work specified by the contract.
{alternative 5} Once the completed network has been approved it shall take precedence over the preliminary network.
{alternative } .....

2.6 PROJECT BREAKDOWN STRUCTURE (PBS)
The Contractor shall use the Owner provided project breakdown structure to serve as guideline to develop the activity coding system and a cost accounting system. *(The Owner must develop a detailed Project Breakdown Structure in the early stages of the project and the latest revised version should be included here as part of the specification or include the following alternative if the owner is not familiar with the development procedure for a PBS - ...)*
{alternative 1} The [Contractor] [Consultant] shall develop the Project Breakdown Structure which will serve as a guideline for cost accounting and schedule development after approved by the owner.
{alternative} .....

2.7 MILESTONE AND IMPOSED DATES
The schedule shall contain and adhere to the following milestone and imposed dates:

MILESTONE CODE	MILESTONE ACTIVITY DESCRIPTION	MILESTONE IMPOSED DATE

(The Owner must provide the desired milestones and imposed dates)

2.8 ACTIVITY SORTING REQUIREMENTS

The computerized analysis shall be performed and reports produced with the sorting code priority indicated from left to right:

> **selection 1** < Activity listing in ascending order of [event code] [activity code]

> **selection 2** < Activity sort by total float - [early start date] - [ ]

> **selection 3** < Activity sort by trade - [early start date] - [float]

> **selection 4** < Activity sort by [event code] [activity code] [owner provided code] [responsibility code] [PBS code] [CSI code] [ ] - [early start date] [ ]

> **selection 5** < Contractor's monthly payment request sorted by [owner provided code] [responsibility code] [PBS code] [CSI code] [ ]

{alternative 1} The sorting requirements shall have the following priority: [early start], [total float], [activity code], [event code], [responsibility code], [*(Remember most CPM software packages have a limited number of priorities that can be included.)*]

{alternative } .....

2.9 NETWORK DIAGRAM DRAFTING REQUIREMENTS

> **selection 1** < All submitted network diagrams shall be [printed] [drafted] on standard [24] [30] inches ([600] [750] mm) high by [36] [42] inches ([1000] [1250] mm) wide.

>**selection 2** < The diagram shall read from left to right .

> **selection 3**< All activities will be identified with applicable sorting codes.

> **selection 4** < The scale and spacing of the activities shall allow space for notations, revisions and addition of new activities.

> **selection 5** < Each page shall include a specific block in the [upper] [lower] right hand corner which indicates the current update revision number.

> **selection 6** < [2] [3] [ ] copies of the network diagram shall be submitted. [1] [2] of those copies shall be reproducible.

> **selection** < .....

2.10REQUIRED REPORTS FOR INITIAL SUBMISSION

> **selection 1** < [2] [3] [5] [ ] copies of the network diagram showing all the required activity information in an organized drawing.

> **selection 2** < [2] [3] [5] [ ] copies of the file printout of all existing activity information from the network database sorted in order of [ascending event code] [ascending activity code]

> **selection 3** < [2] [3] [5] [ ] copies of a list of activities sorted in order of least total float and early start date based on a projected start date.

> **selection 4** < [2] [3] [5] [ ] copies of a list of activities sorted in order of early start for the entire project based on a projected start date.

> **selection 5** < [2] [3] [5] [ ] copies of a list of all activities sorted by [responsibility] [CSI] [PBS] code and early start.

> **selection 6** < [2] [3] [5] [ ] copies of a dependency report showing the predecessor event followed by the successor event for all possible end restraint conditions for each activity sorted in

ascending order of activity code. *(Use this selection only when the Precedence Diagramming Technique is specified.)*
> **selection 7** < [2] [3] [5] [ ] copies of the milestone report listed [in ascending order of activity [event] [code]] [responsibility code] [early start] [completion date].

2.11SPECIALIZED NETWORK ANALYSIS
2.11.1
> **selection 1** < Resource Aggregation is required for the [first [3] [6] [12] [ ] months] [entire project] for the following resources and the following reports shall be submitted: >tabular format for early start dates<, >tabular format for late start dates<, >histogram format for early start dates<, >histogram format for late start dates<, >cumulative early start<, >cumulative late start<.

RESOURCE CODE	RESOURCE DESCRIPTION	UNIT OF MEASURE

2.11.2
> **selection 2** < Resource Leveling will be performed for the following resources: *(The analysis becomes useless if more than 3 resources are listed. Simulation with different priorities is encouraged.)*

PRIORITY	RESOURCE DESCRIPTION	UNIT OF MEASURE
1		
2		

The following reports shall be submitted: >tabular format for each resource<, >histogram format for each resource<, >tabular format for all resources<, >histogram format for all resources<. The final leveled activity report shall be presented as a schedule sorted in order of the activity start date.

2.11.3
>**selection 3** < Resource allocation will be performed considering the following resource availability at the project level: *(After filling in the desired resource and its appropriate unit of measure insert the maximum number of units available just before the "from" and then insert the dates when the resource level restrictions apply.)*

RSC CODE	RESOURCE DESCRIPTION	UNIT OF MEASURE	MAX NO. OF AVAILABLE RESOURCES		
			Units	date	date
				From:	to:
				From:	to:

The final allocated activity report shall be presented as a schedule sorted in order of the activity start date.

PART 3 PROGRES MONITORING AND UPDATING

3.1 UPDATING FREQUENCY

A [bi-monthly] [monthly] [ ] update meeting shall be conducted by the Contractor's Project Manager {Consultant} and appropriate Owner's representatives to update the network and review the Contractor's progress.
{alternative 1} The network database shall be updated on a [daily] [weekly] [monthly] [ ] basis.

3.2 UPDATING PARTICIPATION AND CONTENT
The update meeting shall be [conducted at the Contractor's field office on site] [conducted at the Contractor's home office] [conducted at the office Owner's representative] and attended by the Contractor's project manager, general superintendent, [appropriate subcontractor representatives], [*(add your own)*] and appropriate scheduling personnel to meet with the designated Owner's representative. During the update meeting, the Contractor will describe, on an activity by activity basis, all proposed revisions and adjustments to the network required to reflect the current status of the project. The Owner's representative shall approve activity progress, proposed revisions and adjustments, and the use of any optional calculations.
{alternative 1} If the impacts of certain scheduling changes or update information cannot be properly predicted at the update meeting, the Owner's representative shall have [2] [3] [5] working days after receipt of the updated reports to review and approve the impacts of the revised input. Approval of the updated schedule shall be made in writing.

3.3 UPDATED NETWORK APROVAL
The following shall be specifically addressed:
> selection 1 < The actual start and actual finish dates for all activities in progress or completed since the last update as appropriate.
> selection 2 < The estimated remaining duration for each activity in progress. Progress calculations must be based on remaining duration in work calendar units for each activity.
> selection 3 < The earned value for each activity completed.
> selection 4 < All logic changes pertaining to change orders on which a Notice to Proceed has been issued, contractor proposed changes in activity sequence or durations, and corrections to schedule logic to avoid out of sequence progress.
> selection < .....

3.4 UPDATING TURNOVER TIME
The updated network and required reports shall be provided to the Owner's representative within [48] [72] [ ] hours after the updating meeting.

3.5 UPDATING RECORDS AND PROCEDURES
Attendance and major discussion issues shall be recorded and included as part of the update meeting minutes, which shall be kept for each update meeting. The minutes shall be distributed to each of the attendees and shall become a permanent part of the file record.

3.6 FLOAT MANAGEMENT
Float or slack time is defined as the amount of time between the early start date and the late start date, or the early finish date and the late finish date of any activity in the network schedule.
[option 1] Float or slack time is not for the exclusive use or benefit of either the Owner or the Contractor. The float or slack time belongs to the project and shall be available to anyone that needs it first.
{alternative 1} The Owner will not claim possession of float or slack time [15] [20] calendar days in advance of an activity's expected start date without compensating the contractor.

[option 2] The float or slack time will remain for the exclusive use of the owner.
{alternative 1} The Owner will not claim possession of float or slack time [15] [20] calendar days in advance of an activity's expected start date without compensating the contractor.
[option 3] The float or slack time will remain for the exclusive use of the contractor.
[option] .....

3.7 CHANGE ORDERS
3.7.1 CHANGE ORDER REPRESENTATION
The contractor shall prepare suggested network revisions for all proposed contract changes that impact the approved schedule and submit them as a sub network to the Owner's representative with his price proposal. Each change order shall be represented by at least two activities to include an activity designated for preparatory time and another designated for the actual extra work duration.
{alternative 1} The preparatory activity will have an imposed start date, which is not earlier than the notice to proceed authorized by the owner.

3.7.2 CHANGE ORDER SUMMARY AND DOCUMENTATION
The network revisions shall include a narrative listing of the affected activities including a statement of the expected overall impact of the change proposed, and a sub network of the affected diagram area. When the change order is agreed upon by the Contractor and the Owner's representative, the changed logic and durations shall be utilized in analysis of the overall project.

3.7.3 TIMING OF CHANGE ORDER INCORPORATION
When the Contractor is required to proceed with changes prior to settlement of price and/or time, the Contractor shall submit the same revisions for concurrence by the Owner's representative prior to inclusion in the network diagram.
{alternative 1} If the Contractor fails to submit or include such revision within [10] [ ] days of the notice to proceed, the Owner's representative shall furnish to the contractor the suggested logic and/or revised durations to be entered in the network analysis until the Contractor submits revisions, and the final changes and the associated impacts have been negotiated.
{alternative 1a} If the Contractor has any objections to the data furnished by the Owner's representative, he shall advise the Owner's representative shall be advised promptly of any objections and provide a written counter plan; however, the Contractor will continue to use the revisions by the Owner's representative until such time as the Contractor's alternate plan is approved.
{alternative 1b} If the Contractor fails to submit an alternative plan within [10] [ ] days after the date such suggested revisions were furnished by the Owner's representative, the Contractor will be deemed to have concurred with the Owner's representative suggested logic/duration time changes. The changes then will be the basis for equitable adjustment for the performance of the extra work.
{alternative } .....

3.8 REQUIRED REPORTS AFTER EACH UPDATE
The computerized analysis shall be performed and the following reports shall be produced with the sorting code priority indicated from left to right:

> selection 1 < [2] [ ] copies of the executive summary report indicating the milestone activity completion dates and the completion dates of major sub networks. This report shall include (1) a description of activities and progress along the [4] [ ] most critical paths, (2) a description of

current and anticipated problem areas or delaying factors and their impact, and (3) an explanation of the corrective actions taken.
{alternative 1} Only modifications that have been authorized and approved by the Owner's representative shall be included in the schedule submission.
{alternative 2} The narrative report shall specifically reference, on an activity-by-activity basis, all changes made since the previous period and relate each change to documented, approved schedule changes. *(Please note that the referenced changes refer to changes in activity duration, description, resources per activity, cost, sorting codes and logic.)*
{alternative } .....
> selection 2 < [2] [ ] copies of the overall schedule in ascending order of activity number for the activities remaining to be completed.
> selection 3 < [2] [ ] copies of the schedule sorted in order of least float primary sorting code showing the critical activities first and then by the early start date as a secondary sorting code.
> selection 4 < [2] [ ] copies of the look-ahead bar chart schedule showing major sub networks and milestone activities, which is developed by the CPM software and is based on the CPM data for an upcoming [2] [ ] month interval.
>selection 5 < [2] [ ] copies of the cost report sorted by the responsibility code and early start which shall serve as a monthly request for progress payment.
{alternative 1} This report, along with the progress update meeting described above shall provide the basis for the contractor's progress payment request and the contractor shall be entitled to progress payments determined from the approved update. If the contractor fails or refuses to furnish the information and network data which, in the sole judgment of the Owner, is necessary for verifying the Contractor's progress, the contractor shall be deemed not to have provided a progress payment estimate and, therefore, no progress payments will be made.
{alternative 2} If the schedule updates occur more frequently than one-month intervals, only one request for payment per month will be permitted.

REFERENCES:
1. Barba, E. M. "Utilizing and Specifying Critical Path Method Scheduling Techniques" Construction Specification Institute Convention Presentation, June 1991.
2. Construction Specifications Institute SPECTEXT 01311 "Network Analysis Schedules" Construction Sciences Research Foundation, April 1988.
3. Department of the Navy, Naval Facilities Engineering Command Guide Specification 01311 "Contractor Prepared Network Analysis System" March 1989.
4. General Services Administration - Public Buildings Service Guide Specification "Critical Path Method Scheduling" May 1987.
5. Fairchild, W.E., "CPM Specifications in Construction" thesis presented to the University of Texas at Austin in May 1985 in partial fulfillment of the requirements for the degree of Master of Science in Engineering.
6. Georges, D.R., "An Improved Critical Path Method scheduling Specification for use in the Navy's Military Construction Program" report presented to the University of Texas at Austin in December 1991 in partial fulfillment of the requirements for the degree of Master of Science in Engineering.
7. Meier, H.W., "Library of Specifications Section 01311" 1985.
8. Popescu, C.M., "Scheduling Specifications: The Key to Successful Project Control" Project Management Institute Seminar Proceedings, Sept 1986.

9. Popescu, C.M., "Quality Control and Quality Assurance in Planning and Scheduling", Project Management Institute Seminar Proceedings, Sept 1991.
10. Popescu, C.M., "The Pitfalls of Resource Scheduling", Project Management Institute Seminar Proceedings, Sept 1991.
11. U.S. Army Corps of Engineers Engineering Regulation 1 - 1- 11 "Progress, Schedules, and Network Analysis Systems" 15 March 1990.
12. Watson, W., "Word processing for specifications: A beginners manual", Construction Specifier, Volume 41, Dee 1988, page 108.

Appendix B

Survey Instructions

Instructions. While completing this survey, assume the following:

- Construction project is new (i.e. not a renovation or repair project)
- Project scope is well defined

The goal of this survey is to determine how Project Complexity and Contract Type affect the selection of Planning and Scheduling Specification (P&S) clauses. The survey is divided into three parts based on the following categories of P&S clauses: (1) *General Organization and Responsibilities*, (2) *Scope and Products*, and (3) *Progress Monitoring and Updating*. The survey consists of the tables on pages 1 – 3 (white pages). Filling in the empty, non-shaded, cells of each table with the responses listed below completes the survey. A sample specification has also been provided (see the blue pages, or pages S-1 – S-13) to assist you in determining the content of each P&S clause in the tables.

Contractors should complete the survey from the perspective of a contractor, and owners should complete the survey from the perspective of an owner. The respondent will consider three projects, each with the following Complexity Rating: (1) *high*, (2) *medium*, and (3) *low*. The project characteristics required to meet each rating are listed at the top of each table. The respondent will also evaluate each project (i.e. high, medium, or low) as a Lump Sum Contract and a Cost Reimbursable Contract (listed as LS and CR respectively in the row immediately below the Complexity Ratings). To complete this survey, the respondent should perform the following:

a. Start at clause number 1.1 and work across.

b. Using your experience and expertise, determine if the P&S clause is needed for a hypothetical project that meets the criteria for a Complexity Rating of *high*, *medium*, and *low* for both *Lump Sum* and *Cost Reimbursable* contracts. Place one of the following letters in the corresponding cell:

   (1) ***Y*** – Yes; you feel strongly that this clause should be included in the specification (the benefit outweighs the cost);

   (2) ***N*** – No; you feel strongly that this clause should not be included in the specification (the cost outweighs the benefit); or

   (3) ***U*** – Undecided; you are undecided as to whether this clause should be included in the specification (cost and benefit are of approximately equal value).

c. Move to the next clause and repeat until all empty cells are filled in.

See the following example:

Consider clause number 2.2 (CPM Computer Software to be Used) and a project with a Complexity Rating of "high." The benefit of including this clause clearly outweighs its cost for both Lump Sum and Cost Reimbursable contracts; therefore those cells should be marked with a ***Y*** (see the table below).

	LEGEND **NA** = No. of Construction Activities **NS** = No. of Subcontractors **ND** = No. of CSI Divisions **CE** = Cost of Installed Equipment (long lead items – transformers, elevators, HVAC equip, etc.) **LS** = Lump Sum Contracts (Unit Price or Fixed Price with Escalation) **CR** = Cost Reimbursable Contracts (Cost Plus Percentage, Fixed, Incentive, or Award Fee)	**NA** > 1,000 **NS** > 20 **ND** > 13 **CE** > $250,000 Project Priority = High	
	Complexity Rati	**HIGH**	
No.	**P&S Clause Description ⇓ Contract Ty**	**LS**	**CR**
	Scope and Products		
2.2	CPM Software (or equal) to be Used	***Y***	***Y***

Returning the Survey. After the survey is completed, fax, mail, or email this page and the survey (pages 1 – 3) to one of the following number/addresses:

Postal Address: Leaf A. Ballast
University of Texas at Austin
Civil Engineering, ECJ 5.2
Austin, TX 78712

Fax: 512-471-3191

Email: lcballast@earthlink.net

Survey Disclosure

	Yes	**No**
Do you want your company's name to be maintained confidential (check one)?		
Do you want to receive the results of this survey?		

Respondent's Information (optional)

Company's Name: _____

_____

Appendix C

Survey Results for High Complexity Lump Sum Projects

	A	B	C	D
1				
2	No.	Description	Ctr-A	Ctr-B
3	1.1	Description, References, Standards	Y	Y
4	1.2	Scheduling Responsibility	Y	Y
5	1.3	Minimum Qualifications of Planning and Scheduling Staff	Y	Y
6	1.4	Training Requirement for Contractor, Subcontractor, Owner	N	N
7	1.5	Preliminary Network Submission Deadline	Y	Y
8	1.6	Detailed Network Submission Deadline	Y	Y
9	1.7	Review and Approval Process	N	Y
10	1.8	Cost of Planning/Scheduling and Monitoring	Y	N
11	1.9	Progress Payments for Planning/Scheduling and Monitoring	Y	N
12	1.10	Subcontractor Input	Y	Y
13	1.11	Contractor's Scheduling Plan	Y	Y
14	1.12	Planning/Scheduling and Monitoring Audits	N	N
15	1.13	Confidentiality/Schedule Ownership	Y	N
16	1.14	Computer Access and Security	Y	N
17	2.1	Network Analysis Technique	Y	Y
18	2.2	CPM Software (or equal) to be Used	Y	Y
19	2.3.1	Activity Description	N	Y
20	2.3.2	Activity Duration (Time Units)	Y	Y
21	2.3.3	Activity Coding System	Y	Y
22	2.3.4	Responsibility Codes	Y	Y
23	2.3.5	Activity Level Resources	N	N
24	2.3.6	Project Level Resources	Y	N
25	2.3.7	Activity Costs	N	N
26	2.3.8	Work Calendars	Y	Y
27	2.4.1	Maximum Activity Duration	Y	Y
28	2.4.2	Maximum Activity Costs	N	Y
29	2.4.3	Minimum Number of Activities in the Completed Network	Y	Y
30	2.4.4	Minimum Number of Activities in the Preliminary Network	Y	Y
31	2.5.1	Summary Schedule	Y	Y
32	2.5.2	Preliminary Network	Y	Y
33	2.5.3	Detailed Network	Y	Y
34	2.6	Project Breakdown Structure	Y	N
35	2.7	Milestones and Imposed Dates	Y	Y
36	2.8	Activity Sorting Requirements	Y	Y
37	2.9	Drafting Requirements	Y	Y
38	2.10	Required Reports for Initial Submittal of Completed Network	Y	Y
39	2.11.1	Resource Aggregation	N	N
40	2.11.2	Resource Leveling	N	N
41	2.11.3	Resource Allocation Optimization	N	N
42	3.1	Updating Fequency	Y	Y
43	3.2	Updating Participation	N	Y
44	3.3	Updatd Network Approval	N	Y

	E	F	G	H	I	J	K	L	M	N	O
1											
2	Ctr-C	Ctr-D	Ctr-E	Own-A	Own-B	Nav-A	Nav-B	Nav-C	Nav-D	Nav-E	Nav-F
3	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
4	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
5	Y	Y	Y	Y	Y	Y	Y	U	U	Y	Y
6	Y	Y	N	Y	N	Y	Y	Y	U	Y	Y
7	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	Y
9	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
10	N	Y	N	N	N	N	U	N	Y	N	U
11	Y	Y	N	N	N	N	U	N	Y	N	U
12	Y	N	N	Y	Y	Y	Y	N	Y	Y	Y
13	Y	Y	N	N	Y	Y	Y	N	U	U	Y
14	Y	N	N	Y	Y	Y	U	U	Y	U	Y
15	Y	Y	N	Y	U	N	U	N	N	N	U
16	N	N	N	Y	U	N	Y	N	N	Y	U
17	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
18	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
19	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
20	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
21	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
22	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	Y
23	Y	U	N	Y	Y	Y	Y	U	Y	Y	U
24	Y	U	N	Y	U	N	U	U	Y	Y	U
25	Y	U	N	Y	Y	Y	Y	Y	Y	Y	U
26	Y		Y	Y	Y	Y	U	Y	Y	Y	Y
27	Y	Y	Y	Y	U	Y	U	Y	N	Y	Y
28	Y	U	N	Y	U	N	U	N	N	Y	U
29	Y	Y	N	U	N	N	Y	N	N	Y	Y
30	Y	Y	N	U	N	N	Y	N	N	Y	Y
31	Y	Y	Y	Y	Y	N	Y	N	N	Y	Y
32	Y	Y	Y	Y	Y	N	Y	N	N	Y	Y
33	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
34	Y	U	N	U	Y	N	U	N	Y	Y	Y
35	Y	Y	Y	Y	Y	Y	U	N	Y	N	Y
36	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
37	N	U	Y	U	U	Y	Y	Y	Y	Y	Y
38		N	Y	Y	Y	Y	Y	Y	Y	Y	Y
39	Y	U	N	Y	U	N	U	N	Y	Y	N
40	Y	U	N	Y	Y	N	Y	N	Y	Y	N
41	Y	U	N	Y	U	N	U	N	Y	Y	N
42	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
43	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
44	Y	N	Y	Y	Y	Y	U	Y	Y	U	Y

	P	Q	R	S	T	U
1	Nav-G	Nav-H	Totals			Clause
2			Yes	Und	No	Desirability
3	Y	Y	13	0	2	2.600
4	Y	Y	14	0	1	2.800
5	Y	Y	13	2	0	2.800
6	Y	Y	10	1	4	2.100
7	Y	Y	15	0	0	3.000
8	Y	Y	14	1	0	2.900
9	Y	Y	13	0	2	2.600
10	N	Y	4	2	9	1.000
11	N	Y	5	2	8	1.200
12	Y	Y	12	0	3	2.400
13	N	Y	9	2	4	2.000
14	Y	Y	8	3	4	1.900
15	N	Y	5	3	7	1.300
16	N	Y	5	2	8	1.200
17	Y	Y	14	0	1	2.800
18	Y	Y	14	0	1	2.800
19	Y	Y	14	0	1	2.800
20	Y	Y	15	0	0	3.000
21	Y	Y	15	0	0	3.000
22	Y	Y	14	1	0	2.900
23	Y	Y	9	3	3	2.100
24	Y	Y	7	5	3	1.900
25	Y	Y	10	2	3	2.200
26	Y	Y	13	1	0	2.893
27	Y	Y	12	2	1	2.600
28	Y	Y	6	4	5	1.600
29	Y	Y	9	1	5	1.900
30	Y	Y	9	1	5	1.900
31	Y	Y	12	0	3	2.400
32	Y	Y	12	0	3	2.400
33	Y	Y	14	0	1	2.800
34	U	Y	7	4	4	1.800
35	U	Y	11	2	2	2.400
36	Y	Y	15	0	0	3.000
37	Y	Y	11	3	1	2.500
38	N	Y	12	0	2	2.571
39	N	Y	5	3	7	1.300
40	N	Y	7	1	7	1.500
41	N	Y	5	3	7	1.300
42	Y	Y	15	0	0	3.000
43	Y	Y	12	0	3	2.400
44	Y	Y	11	2	2	2.400

	A	B	C	D
45	3.4	Updating Turnover Time	N	Y
46	3.5	Updating Records and Reporting	N	Y
47	3.6	Float Management	Y	Y
48	3.7.1	Change Order Representation	N	Y
49	3.7.2	Change Order Summary/Documentation	N	Y
50	3.7.3	Timing of Change Order Incorporation	N	Y
51	3.8	Required Reports at Each Update	N	Y
52		Specification Desirability	1.898	2.204

	E	F	G	H	I	J	K	L	M	N	O
45	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
46	Y	Y	Y	U	Y	Y	Y	N	Y	Y	Y
47	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y
48	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
49	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
50	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Y
51	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
52	2.813	2.344	1.898	2.602	2.296	2.082	2.602	1.286	2.418	2.602	2.571

	P	Q	R	S	T	U
45	Y	Y	13	0	2	2.600
46	N	Y	11	1	3	2.300
47	Y	Y	12	0	3	2.400
48	Y	Y	14	0	1	2.800
49	Y	Y	14	0	1	2.800
50	N	Y	12	1	2	2.500
51	N	Y	12	0	3	2.400
52	2.204	3.000	10.98	1.184	2.796	2.322

Appendix D

Survey Results for Medium Complexity Lump Sum Projects

	A	B	C	D
1 2	No.	Description	Ctr-A	Ctr-B
3	1.1	Description, References, Standards	N	Y
4	1.2	Scheduling Responsibility	N	Y
5	1.3	Minimum Qualifications of Planning and Scheduling Staff	N	N
6	1.4	Training Requirement for Contractor, Subcontractor, Owner	N	N
7	1.5	Preliminary Network Submission Deadline	N	Y
8	1.6	Detailed Network Submission Deadline	N	Y
9	1.7	Review and Approval Process	N	Y
10	1.8	Cost of Planning/Scheduling and Monitoring	Y	N
11	1.9	Progress Payments for Planning/Scheduling and Monitoring	Y	N
12	1.10	Subcontractor Input	N	N
13	1.11	Contractor's Scheduling Plan	N	N
14	1.12	Planning/Scheduling and Monitoring Audits	N	N
15	1.13	Confidentiality/Schedule Ownership	Y	N
16	1.14	Computer Access and Security	N	N
17	2.1	Network Analysis Technique	N	Y
18	2.2	CPM Software (or equal) to be Used	Y	Y
19	2.3.1	Activity Description	N	Y
20	2.3.2	Activity Duration (Time Units)	N	Y
21	2.3.3	Activity Coding System	N	Y
22	2.3.4	Responsibility Codes	N	Y
23	2.3.5	Activity Level Resources	N	N
24	2.3.6	Project Level Resources	N	N
25	2.3.7	Activity Costs	N	N
26	2.3.8	Work Calendars	Y	Y
27	2.4.1	Maximum Activity Duration	Y	Y
28	2.4.2	Maximum Activity Costs	N	N
29	2.4.3	Minimum Number of Activities in the Completed Network	N	N
30	2.4.4	Minimum Number of Activities in the Preliminary Network	N	N
31	2.5.1	Summary Schedule	Y	Y
32	2.5.2	Preliminary Network	N	Y
33	2.5.3	Detailed Network	N	Y
34	2.6	Project Breakdown Structure	Y	N
35	2.7	Milestones and Imposed Dates	Y	Y
36	2.8	Activity Sorting Requirements	N	Y
37	2.9	Drafting Requirements	N	N
38	2.10	Required Reports for Initial Submittal of Completed Network	N	N
39	2.11.1	Resource Aggregation	N	N
40	2.11.2	Resource Leveling	N	N
41	2.11.3	Resource Allocation Optimization	N	N
42	3.1	Updating Fequency	N	Y
43	3.2	Updating Participation	N	Y
44	3.3	Updatd Network Approval	N	Y

	E	F	G	H	I	J	K	L	M	N	O
1 2	Ctr-C	Ctr-E	Own-A	Own-B	Nav-A	Nav-B	Nav-C	Nav-D	Nav-E	Nav-F	Nav-G
3	N	Y	Y	N	N	Y	Y	U	Y	U	Y
4	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
5	Y	N	Y	N	Y	U	U	U	Y	Y	N
6	N	N	Y	N	Y	U	Y	U	N	N	N
7	Y	Y	Y	N	N	U	Y	U	Y	N	Y
8	Y	Y	Y	N	Y	Y	U	Y	Y	Y	Y
9	Y	Y	Y	N	Y	U	N	Y	N	N	Y
10	N	N	N	N	N	U	N	Y	N	N	N
11	Y	N	N	N	N	U	N	Y	N	N	N
12	Y	N	N	N	Y	U	N	Y	Y	Y	N
13	Y	N	N	Y	N	U	N	N	U	U	N
14	N	N	N	N	N	U	U	Y	U	U	Y
15	Y	N	Y	U	N	U	N	N	N	N	N
16	N	N	Y	U	N	Y	N	N	Y	N	N
17	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
18	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
19	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	Y
20	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
21	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
22	Y	N	Y	Y	Y	Y	U	Y	Y	Y	Y
23	Y	N	Y	Y	Y	Y	U	Y	Y	N	Y
24	Y	N	Y	U	N	U	U	Y	Y	N	N
25	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y
26	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y
27	Y	Y	Y	U	Y	U	Y	N	Y	Y	Y
28	Y	N	Y	U	N	U	N	N	Y	N	Y
29	Y	N	U	N	N	U	N	N	Y	Y	Y
30	Y	N	U	N	N	Y	N	N	Y	Y	Y
31	Y	Y	Y	N	N	Y	N	N	Y	Y	Y
32	Y	Y	Y	N	N	Y	N	N	Y	N	Y
33	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
34	Y	N	U	Y	N	U	N	N	Y	N	N
35	Y	Y	Y	Y	Y	U	N	Y	N	U	N
36	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	N
37	N	N	U	U	Y	Y	Y	Y	Y	Y	N
38		N	Y	Y	Y	U	Y	Y	U	Y	N
39	N	N	N	U	N	U	N	N	U	N	N
40	N	N	N	Y	N	U	N	N	U	N	N
41	N	N	N	U	N	U	N	N	U	N	N
42	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
43	Y	Y	Y	Y	Y	U	N	Y	U	Y	Y
44	Y	N	Y	Y	Y	U	Y	Y	U	Y	Y

	P	Q	R	S	T
1	Nav-H	Totals			Clause
2		Yes	Und	No	Desirability
3	Y	8	2	4	1.929
4	Y	12	0	2	2.571
5	U	5	4	5	1.500
6	U	3	3	8	0.964
7	U	7	3	4	1.821
8	U	10	2	2	2.357
9	U	7	2	5	1.714
10	U	2	2	10	0.643
11	Y	4	1	9	0.964
12	U	5	2	7	1.286
13	Y	3	3	8	0.964
14	U	2	5	7	0.964
15	U	3	3	8	0.964
16	Y	4	1	9	0.964
17	U	11	1	2	2.464
18	U	12	1	1	2.679
19	U	11	2	1	2.571
20	U	12	1	1	2.679
21	U	12	1	1	2.679
22	U	10	2	2	2.357
23	U	8	2	4	1.929
24	U	4	4	6	1.286
25	U	9	1	4	2.036
26	U	12	2	0	2.786
27	N	10	2	2	2.357
28	U	4	3	7	1.179
29	U	4	3	7	1.179
30	U	5	2	7	1.286
31	U	9	1	4	2.036
32	U	7	1	6	1.607
33	U	11	1	2	2.464
34	Y	5	2	7	1.286
35	Y	9	2	3	2.143
36	Y	11	1	2	2.464
37	Y	7	2	5	1.714
38	Y	7	2	4	1.846
39	N	0	3	11	0.321
40	N	1	2	11	0.429
41	U	0	4	10	0.429
42	U	12	1	1	2.679
43	U	9	3	2	2.250
44	U	9	3	2	2.250

	A	B	C	D
45	3.4	Updating Turnover Time	N	Y
46	3.5	Updating Records and Reporting	N	Y
47	3.6	Float Management	Y	Y
48	3.7.1	Change Order Representation	N	N
49	3.7.2	Change Order Summary/Documentation	N	N
50	3.7.3	Timing of Change Order Incorporation	N	N
51	3.8	Required Reports at Each Update	N	N
52		Specification Desirability	0.612	1.469

	E	F	G	H	I	J	K	L	M	N	O
45	Y	N	Y	Y	Y	U	N	Y	Y	Y	Y
46	Y	Y	U	Y	Y	U	N	Y	Y	Y	N
47	Y	Y	N	N	Y	Y	N	Y	N	Y	Y
48	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
49	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y
50	Y	N	Y	U	Y	Y	Y	Y	Y	Y	N
51	Y	N	Y	Y	Y	U	N	Y	Y	Y	N
52	2.438	1.286	2.296	1.684	1.898	2.173	1.286	2.051	2.327	1.898	1.776

	P	Q	R	S	T
45	U	9	2	3	2.143
46	U	8	3	3	2.036
47	U	9	1	4	2.036
48	U	10	1	3	2.250
49	U	9	1	4	2.036
50	U	8	2	4	1.929
51	U	7	2	5	1.714
52	1.714	7.265	2.041	4.673	1.778

Appendix E

Survey Results for Low Complexity Lump Sum Projects

	A	B	C	D
1				
2	No.	Description	Ctr-A	Ctr-B
3	1.1	Description, References, Standards	N	Y
4	1.2	Scheduling Responsibility	N	Y
5	1.3	Minimum Qualifications of Planning and Scheduling Staff	N	N
6	1.4	Training Requirement for Contractor, Subcontractor, Owner	N	N
7	1.5	Preliminary Network Submission Deadline	N	N
8	1.6	Detailed Network Submission Deadline	N	N
9	1.7	Review and Approval Process	N	N
10	1.8	Cost of Planning/Scheduling and Monitoring	Y	N
11	1.9	Progress Payments for Planning/Scheduling and Monitoring	Y	N
12	1.10	Subcontractor Input	N	N
13	1.11	Contractor's Scheduling Plan	N	N
14	1.12	Planning/Scheduling and Monitoring Audits	N	N
15	1.13	Confidentiality/Schedule Ownership	Y	N
16	1.14	Computer Access and Security	N	N
17	2.1	Network Analysis Technique	N	N
18	2.2	CPM Software (or equal) to be Used	Y	N
19	2.3.1	Activity Description	N	Y
20	2.3.2	Activity Duration (Time Units)	N	Y
21	2.3.3	Activity Coding System	N	N
22	2.3.4	Responsibility Codes	N	N
23	2.3.5	Activity Level Resources	N	N
24	2.3.6	Project Level Resources	N	N
25	2.3.7	Activity Costs	N	N
26	2.3.8	Work Calendars	N	Y
27	2.4.1	Maximum Activity Duration	N	N
28	2.4.2	Maximum Activity Costs	N	N
29	2.4.3	Minimum Number of Activities in the Completed Network	N	N
30	2.4.4	Minimum Number of Activities in the Preliminary Network	N	N
31	2.5.1	Summary Schedule	N	Y
32	2.5.2	Preliminary Network	Y	Y
33	2.5.3	Detailed Network	N	Y
34	2.6	Project Breakdown Structure	N	N
35	2.7	Milestones and Imposed Dates	Y	N
36	2.8	Activity Sorting Requirements	N	N
37	2.9	Drafting Requirements	N	N
38	2.10	Required Reports for Initial Submittal of Completed Network	N	N
39	2.11.1	Resource Aggregation	N	N
40	2.11.2	Resource Leveling	N	N
41	2.11.3	Resource Allocation Optimization	N	N
42	3.1	Updating Fequency	N	Y
43	3.2	Updating Participation	N	Y
44	3.3	Updatd Network Approval	N	Y

	E	F	G	H	I	J	K	L	M	N	O
1											
2	Ctr-C	Ctr-E	Own-A	Own-B	Nav-A	Nav-B	Nav-C	Nav-D	Nav-E	Nav-F	Nav-G
3	N	N	Y	N	N	Y	U	N	Y	N	Y
4	Y	N	Y	Y	Y	Y	N	Y	Y	N	Y
5	N	N	N	N	N	N	U	U	Y	N	N
6	N	N	N	N	N	N	N	U	N	N	N
7	N	N	Y	N	N	N	U	N	Y	N	Y
8	Y	N	Y	N	Y	Y	U	N	Y	N	Y
9	Y	N	N	N	Y	U	N	Y	N	N	Y
10	N	N	N	N	N	N	N	Y	N	N	N
11	N	N	N	N	N	N	N	Y	N	N	N
12	Y	N	N	N	Y	N	N	Y	N	N	N
13	N	N	N	N	N	N	N	N	N	N	N
14	N	N	N	N	N	N	U	Y	N	N	Y
15	Y	N	Y	U	N	U	N	N	N	N	N
16	N	N	Y	U	N	Y	N	N	Y	N	N
17	Y	N	Y	N	Y	Y	U	Y	Y	N	N
18	Y	N	Y	Y	Y	Y	N	Y	Y	N	Y
19	Y	N	Y	Y	Y	U	U	N	Y	N	Y
20	Y	N	Y	Y	Y	Y	U	Y	Y	N	Y
21	Y	N	Y	Y	Y	N	U	N	Y	N	Y
22	Y	N	N	Y	Y	Y	U	N	Y	N	Y
23	Y	N	N	Y	Y	Y	U	N	U	N	N
24	Y	N	N	U	N	U	U	N	U	N	N
25	Y	N	Y	Y	Y	Y	U	N	N	N	Y
26	Y	N	Y	Y	Y	U	U	N	N	N	Y
27	N	N	N	U	Y	U	U	N	Y	N	Y
28	N	N	N	U	N	U	N	N	N	N	Y
29	N	N	U	N	N	N	N	N	Y	N	Y
30	N	N	U	N	N	Y	N	N	Y	N	Y
31	N	N	N	N	N	Y	N	N	N	N	Y
32	N	N	N	N	N	Y	N	N	Y	N	Y
33	N	N	N	Y	Y	Y	N	Y	Y	N	N
34	N	N	U	Y	N	U	N	N	U	N	N
35	N	N	Y	N	Y	U	N	Y	N	N	N
36	N	N	Y	Y	Y	N	U	N	Y	N	N
37	N	N	U	U	Y	Y	U	Y	N	N	N
38		N	Y	Y	Y	N	U	N	U	N	N
39	N	N	N	U	N	N	N	N	N	N	N
40	N	N	N	Y	N	U	N	N	N	N	N
41	N	N	N	U	N	N	N	N	N	N	N
42	N	N	Y	Y	Y	U	U	Y	Y	N	Y
43	N	N	Y	Y	Y	U	N	Y	N	N	Y
44	N	N	Y	Y	Y	U	U	Y	N	N	Y

	P	Q	R	S	T
1	Nav-H		Totals		Clause
2		Yes	Und	No	Desirability
3	Y	6	1	7	1.393
4	Y	10	0	4	2.143
5	N	1	2	11	0.429
6	N	0	1	13	0.107
7	N	3	1	10	0.750
8	N	6	1	7	1.393
9	N	4	1	9	0.964
10	N	2	0	12	0.429
11	Y	3	0	11	0.643
12	N	3	0	11	0.643
13	Y	1	0	13	0.214
14	N	2	1	11	0.536
15	N	3	2	9	0.857
16	Y	4	1	9	0.964
17	N	6	1	7	1.393
18	N	9	0	5	1.929
19	N	7	2	5	1.714
20	N	9	1	4	2.036
21	N	6	1	7	1.393
22	N	6	1	7	1.393
23	N	4	2	8	1.071
24	N	1	4	9	0.643
25	N	6	1	7	1.393
26	N	6	2	6	1.500
27	N	3	3	8	0.964
28	N	1	2	11	0.429
29	N	2	1	11	0.536
30	N	3	1	10	0.750
31	N	3	0	11	0.643
32	N	5	0	9	1.071
33	N	6	0	8	1.286
34	N	1	3	10	0.536
35	N	4	1	9	0.964
36	N	4	1	9	0.964
37	N	3	3	8	0.964
38	N	3	2	8	0.923
39	N	0	1	13	0.107
40	N	1	1	12	0.321
41	N	0	1	13	0.107
42	N	7	2	5	1.714
43	N	6	1	7	1.393
44	N	6	2	6	1.500

	A	B	C	D
45	3.4	Updating Turnover Time	N	Y
46	3.5	Updating Records and Reporting	N	Y
47	3.6	Float Management	N	Y
48	3.7.1	Change Order Representation	N	N
49	3.7.2	Change Order Summary/Documentation	N	N
50	3.7.3	Timing of Change Order Incorporation	N	N
51	3.8	Required Reports at Each Update	N	N
52		Specification Desirability	0.367	0.857

	E	F	G	H	I	J	K	L	M	N	O
45	N	N	Y	Y	Y	U	N	Y	Y	N	Y
46	N	N	U	Y	Y	U	N	Y	Y	N	N
47	N	N	N	N	Y	Y	N	Y	N	N	Y
48	N	N	Y	Y	Y	Y	U	Y	Y	N	N
49	N	N	N	N	Y	Y	U	Y	Y	N	N
50	N	N	Y	U	Y	Y	U	Y	Y	N	N
51	N	N	Y	Y	Y	U	N	Y	Y	N	N
52	0.938	0.000	1.561	1.561	1.776	1.653	0.704	1.408	1.653	0.000	1.469

	P	Q	R	S	T
45	N	7	1	6	1.607
46	N	5	2	7	1.286
47	N	5	0	9	1.071
48	N	6	1	7	1.393
49	N	4	1	9	0.964
50	N	5	2	7	1.286
51	N	5	1	8	1.179
52	0.306	4.143	1.204	8.633	1.018

Appendix F

Survey Results for High Complexity Cost Reimbursable Projects

	A	B	C	D
1	No.	Description	Ctr-A	Ctr-B
2				
3	1.1	Description, References, Standards	Y	Y
4	1.2	Scheduling Responsibility	Y	Y
5	1.3	Minimum Qualifications of Planning and Scheduling Staff	Y	Y
6	1.4	Training Requirement for Contractor, Subcontractor, Owner	N	N
7	1.5	Preliminary Network Submission Deadline	Y	Y
8	1.6	Detailed Network Submission Deadline	Y	Y
9	1.7	Review and Approval Process	N	Y
10	1.8	Cost of Planning/Scheduling and Monitoring	Y	Y
11	1.9	Progress Payments for Planning/Scheduling and Monitoring	Y	Y
12	1.10	Subcontractor Input	Y	Y
13	1.11	Contractor's Scheduling Plan	Y	Y
14	1.12	Planning/Scheduling and Monitoring Audits	N	Y
15	1.13	Confidentiality/Schedule Ownership	Y	N
16	1.14	Computer Access and Security	Y	N
17	2.1	Network Analysis Technique	Y	Y
18	2.2	CPM Software (or equal) to be Used	Y	Y
19	2.3.1	Activity Description	N	Y
20	2.3.2	Activity Duration (Time Units)	Y	Y
21	2.3.3	Activity Coding System	Y	Y
22	2.3.4	Responsibility Codes	Y	Y
23	2.3.5	Activity Level Resources	N	N
24	2.3.6	Project Level Resources	Y	N
25	2.3.7	Activity Costs	Y	N
26	2.3.8	Work Calendars	Y	Y
27	2.4.1	Maximum Activity Duration	Y	Y
28	2.4.2	Maximum Activity Costs	N	Y
29	2.4.3	Minimum Number of Activities in the Completed Network	Y	Y
30	2.4.4	Minimum Number of Activities in the Preliminary Network	Y	Y
31	2.5.1	Summary Schedule	Y	Y
32	2.5.2	Preliminary Network	Y	Y
33	2.5.3	Detailed Network	Y	Y
34	2.6	Project Breakdown Structure	Y	N
35	2.7	Milestones and Imposed Dates	Y	Y
36	2.8	Activity Sorting Requirements	Y	Y
37	2.9	Drafting Requirements	Y	Y
38	2.10	Required Reports for Initial Submittal of Completed Network	Y	Y
39	2.11.1	Resource Aggregation	N	N
40	2.11.2	Resource Leveling	N	N
41	2.11.3	Resource Allocation Optimization	N	N
42	3.1	Updating Fequency	Y	Y
43	3.2	Updating Participation	Y	Y
44	3.3	Updatd Network Approval	Y	Y

	E	F	G	H	I	J	K	L	M	N	O
1											
2	Ctr-C	Ctr-D	Ctr-E	Own-A	Own-B	Nav-B	Nav-C	Nav-D	Nav-E	Nav-F	Nav-G
3	U	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
4	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
5	Y	Y	Y	Y	Y	Y	U	U	Y	Y	Y
6	U	Y	N	Y	N	Y	Y	U	Y	Y	Y
7	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	Y
9	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
10	N	Y	N	N	N	U	N	Y	N	Y	N
11	N	Y	N	N	N	U	N	Y	N	Y	N
12	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y
13	Y	Y	N	N	Y	Y	N	U	U	Y	N
14	N	N	N	Y	Y	U	U	Y	U	Y	Y
15	Y	Y	N	Y	U	U	N	N	N	U	N
16	N	N	N	Y	U	Y	N	N	Y	U	N
17	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
18	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
19	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
20	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
21	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
22	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	Y
23	Y	U	N	Y	Y	Y	U	Y	Y	Y	Y
24	Y	U	N	Y	U	U	U	Y	Y	Y	Y
25	Y	U	N	Y	Y	Y	Y	Y	Y	Y	Y
26	Y		Y	Y	Y	U	Y	Y	Y	Y	Y
27	Y	Y	Y	Y	U	U	Y	N	Y	Y	Y
28	Y	U	N	Y	U	U	N	N	Y	Y	Y
29	Y	Y	N	U	N	Y	N	N	Y	Y	Y
30	Y	Y	N	U	N	Y	N	N	Y	Y	Y
31	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y
32	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y
33	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
34	Y	U	N	U	Y	U	N	Y	Y	Y	U
35	Y	Y	Y	Y	Y	U	N	Y	N	Y	U
36	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Y
37	N	U	Y	U	U	Y	Y	Y	Y	Y	Y
38		N	Y	Y	Y	Y	Y	Y	Y	Y	N
39	Y	U	N	Y	U	U	N	Y	Y	Y	N
40	Y	U	N	Y	Y	Y	N	Y	Y	Y	N
41	Y	U	N	Y	U	U	N	Y	Y	Y	N
42	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
43	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
44	Y	N	Y	Y	Y	U	Y	Y	U	Y	Y

	P	Q	R	S	T
1	Nav-H	Totals			Clause
2		Yes	Und	No	Desirability
3	Y	12	1	1	2.679
4	Y	13	0	1	2.786
5	Y	12	2	0	2.786
6	Y	8	2	4	1.929
7	Y	14	0	0	3.000
8	Y	13	1	0	2.893
9	Y	12	0	2	2.571
10	Y	6	1	7	1.393
11	Y	6	1	7	1.393
12	Y	12	0	2	2.571
13	Y	8	2	4	1.929
14	Y	7	3	4	1.821
15	Y	5	3	6	1.393
16	Y	5	2	7	1.286
17	Y	13	0	1	2.786
18	Y	13	0	1	2.786
19	Y	13	0	1	2.786
20	Y	14	0	0	3.000
21	Y	14	0	0	3.000
22	Y	13	1	0	2.893
23	Y	9	2	3	2.143
24	Y	8	4	2	2.143
25	Y	11	1	2	2.464
26	Y	12	1	0	2.885
27	Y	11	2	1	2.571
28	Y	7	3	4	1.821
29	Y	9	1	4	2.036
30	Y	9	1	4	2.036
31	Y	12	0	2	2.571
32	Y	12	0	2	2.571
33	Y	13	0	1	2.786
34	Y	7	4	3	1.929
35	Y	10	2	2	2.357
36	Y	13	1	0	2.893
37	Y	10	3	1	2.464
38	Y	11	0	2	2.538
39	Y	6	3	5	1.607
40	Y	8	1	5	1.821
41	Y	6	3	5	1.607
42	Y	14	0	0	3.000
43	Y	13	0	1	2.786
44	Y	11	2	1	2.571

	A	B	C	D
45	3.4	Updating Turnover Time	Y	Y
46	3.5	Updating Records and Reporting	Y	Y
47	3.6	Float Management	Y	Y
48	3.7.1	Change Order Representation	Y	Y
49	3.7.2	Change Order Summary/Documentation	Y	Y
50	3.7.3	Timing of Change Order Incorporation	Y	Y
51	3.8	Required Reports at Each Update	Y	Y
52		Specification Desirability	2.449	2.388

	E	F	G	H	I	J	K	L	M	N	O
45	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
46	Y	Y	Y	U	Y	Y	N	Y	Y	Y	N
47	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y
48	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
49	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
50	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	N
51	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N
52	2.625	2.375	1.898	2.663	2.296	2.602	1.286	2.418	2.602	2.939	2.204

	P	Q	R	S	T
45	Y	13	0	1	2.786
46	Y	11	1	2	2.464
47	Y	12	0	2	2.571
48	Y	13	0	1	2.786
49	Y	14	0	0	3.000
50	Y	12	1	1	2.679
51	Y	12	0	2	2.571
52	3.000	10.653	1.122	2.184	2.411

Appendix G

Survey Results for Medium Complexity Cost Reimbursable Projects

	A	B	C	D
1	No.	Description	Ctr-A	Ctr-B
2				
3	1.1	Description, References, Standards	Y	Y
4	1.2	Scheduling Responsibility	Y	Y
5	1.3	Minimum Qualifications of Planning and Scheduling Staff	Y	N
6	1.4	Training Requirement for Contractor, Subcontractor, Owner	N	N
7	1.5	Preliminary Network Submission Deadline	Y	Y
8	1.6	Detailed Network Submission Deadline	N	Y
9	1.7	Review and Approval Process	N	Y
10	1.8	Cost of Planning/Scheduling and Monitoring	Y	Y
11	1.9	Progress Payments for Planning/Scheduling and Monitoring	Y	Y
12	1.10	Subcontractor Input	N	N
13	1.11	Contractor's Scheduling Plan	N	N
14	1.12	Planning/Scheduling and Monitoring Audits	N	N
15	1.13	Confidentiality/Schedule Ownership	Y	N
16	1.14	Computer Access and Security	N	N
17	2.1	Network Analysis Technique	Y	Y
18	2.2	CPM Software (or equal) to be Used	Y	Y
19	2.3.1	Activity Description	N	Y
20	2.3.2	Activity Duration (Time Units)	N	Y
21	2.3.3	Activity Coding System	N	Y
22	2.3.4	Responsibility Codes	Y	Y
23	2.3.5	Activity Level Resources	N	N
24	2.3.6	Project Level Resources	N	N
25	2.3.7	Activity Costs	Y	N
26	2.3.8	Work Calendars	Y	Y
27	2.4.1	Maximum Activity Duration	Y	Y
28	2.4.2	Maximum Activity Costs	N	N
29	2.4.3	Minimum Number of Activities in the Completed Network	N	N
30	2.4.4	Minimum Number of Activities in the Preliminary Network	N	N
31	2.5.1	Summary Schedule	Y	Y
32	2.5.2	Preliminary Network	Y	Y
33	2.5.3	Detailed Network	N	Y
34	2.6	Project Breakdown Structure	Y	N
35	2.7	Milestones and Imposed Dates	Y	Y
36	2.8	Activity Sorting Requirements	N	Y
37	2.9	Drafting Requirements	N	N
38	2.10	Required Reports for Initial Submittal of Completed Network	N	N
39	2.11.1	Resource Aggregation	N	N
40	2.11.2	Resource Leveling	N	N
41	2.11.3	Resource Allocation Optimization	N	N
42	3.1	Updating Fequency	N	Y
43	3.2	Updating Participation	N	Y
44	3.3	Updatd Network Approval	N	Y

	E	F	G	H	I	J	K	L	M	N	O
1 2	Ctr-C	Ctr-E	Own-A	Own-B	Nav-B	Nav-C	Nav-D	Nav-E	Nav-F	Nav-G	Nav-H
3	N	Y	Y	N	Y	Y	U	Y	U	Y	Y
4	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
5	U	N	Y	N	U	U	U	Y	Y	N	U
6	N	N	Y	N	U	Y	U	N	N	N	U
7	N	Y	Y	N	U	Y	U	Y	N	Y	U
8	Y	Y	Y	N	Y	U	Y	Y	Y	Y	U
9	Y	Y	Y	N	U	N	Y	N	N	Y	U
10	N	N	N	N	U	N	Y	N	N	N	U
11	N	N	N	N	U	N	Y	N	N	N	Y
12	Y	N	N	N	U	N	Y	Y	Y	N	U
13	N	N	N	Y	U	N	N	U	U	N	Y
14	N	N	N	N	U	U	Y	U	U	Y	U
15	Y	N	Y	U	U	N	N	N	N	N	U
16	N	N	Y	U	Y	N	N	Y	N	N	U
17	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	U
18	N	Y	Y	Y	Y	N	Y	Y	Y	Y	U
19	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	U
20	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U
21	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U
22	Y	N	Y	Y	Y	U	Y	Y	Y	Y	U
23	Y	N	Y	Y	Y	U	Y	U	Y	Y	U
24	Y	N	Y	U	U	U	Y	U	Y	N	U
25	Y	N	Y	Y	Y	Y	Y	U	Y	Y	U
26	Y	Y	Y	Y	U	Y	Y	U	Y	Y	U
27	Y	Y	Y	U	U	Y	N	Y	Y	Y	N
28	Y	N	Y	U	U	N	N	U	Y	Y	U
29	Y	N	U	N	U	N	N	Y	Y	Y	U
30	Y	N	U	N	Y	N	N	Y	Y	Y	U
31	Y	Y	Y	N	Y	N	N	U	Y	Y	U
32	Y	Y	Y	N	Y	N	N	Y	N	Y	U
33	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	U
34	Y	N	U	Y	U	N	N	Y	N	N	Y
35	Y	Y	Y	Y	U	N	Y	N	U	N	Y
36	Y	Y	Y	Y	U	Y	Y	Y	Y	N	Y
37	N	N	U	U	Y	Y	Y	Y	Y	N	Y
38		N	Y	Y	U	Y	Y	U	Y	N	Y
39	N	N	N	U	U	N	N	U	Y	N	N
40	N	N	N	Y	U	N	N	U	Y	N	N
41	N	N	N	U	U	N	N	U	Y	N	U
42	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	U
43	N	Y	Y	Y	U	N	Y	U	Y	Y	U
44	N	N	Y	Y	U	Y	Y	U	Y	Y	U

	P	Q	R	S
1	Totals			Clause
2	Yes	Und	No	Desirability
3	9	2	2	2.308
4	12	0	1	2.769
5	4	5	4	1.500
6	2	3	8	0.808
7	7	3	3	1.962
8	9	2	2	2.308
9	6	2	5	1.615
10	3	2	8	0.923
11	4	1	8	1.038
12	4	2	7	1.154
13	2	3	8	0.808
14	2	5	6	1.038
15	3	3	7	1.038
16	3	2	8	0.923
17	11	1	1	2.654
18	10	1	2	2.423
19	10	2	1	2.538
20	11	1	1	2.654
21	11	1	1	2.654
22	10	2	1	2.538
23	7	3	3	1.962
24	4	5	4	1.500
25	9	2	2	2.308
26	10	3	0	2.654
27	9	2	2	2.308
28	4	4	5	1.385
29	4	3	6	1.269
30	5	2	6	1.385
31	8	2	3	2.077
32	8	1	4	1.962
33	10	1	2	2.423
34	5	2	6	1.385
35	8	2	3	2.077
36	10	1	2	2.423
37	6	2	5	1.615
38	6	2	4	1.750
39	1	3	9	0.577
40	2	2	9	0.692
41	1	4	8	0.692
42	10	1	2	2.423
43	7	3	3	1.962
44	7	3	3	1.962

	A	B	C	D
45	3.4	Updating Turnover Time	N	Y
46	3.5	Updating Records and Reporting	N	Y
47	3.6	Float Management	Y	Y
48	3.7.1	Change Order Representation	N	N
49	3.7.2	Change Order Summary/Documentation	N	N
50	3.7.3	Timing of Change Order Incorporation	N	N
51	3.8	Required Reports at Each Update	N	N
52		Specification Desirability	1.102	1.592

	E	F	G	H	I	J	K	L	M	N	O
45	N	N	Y	Y	U	N	Y	Y	Y	Y	U
46	N	Y	U	Y	U	N	Y	Y	Y	N	U
47	N	Y	Y	N	Y	N	Y	N	Y	Y	U
48	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	U
49	Y	N	Y	N	Y	Y	Y	Y	Y	Y	U
50	Y	N	Y	U	Y	Y	Y	Y	Y	N	U
51	Y	N	Y	Y	U	N	Y	Y	Y	N	U
52	1.781	1.286	2.357	1.684	2.173	1.286	2.051	2.143	2.327	1.776	1.684

	P	Q	R	S
45	7	2	4	1.846
46	6	3	4	1.731
47	8	1	4	1.962
48	9	1	3	2.192
49	8	1	4	1.962
50	7	2	4	1.846
51	6	2	5	1.615
52	6.633	2.204	4.143	1.788

Appendix H

Survey Results for Low Complexity Cost Reimbursable Projects

	A	B	C	D
1	No.	Description	Ctr-A	Ctr-B
2				
3	1.1	Description, References, Standards	N	Y
4	1.2	Scheduling Responsibility	N	Y
5	1.3	Minimum Qualifications of Planning and Scheduling Staff	N	N
6	1.4	Training Requirement for Contractor, Subcontractor, Owner	N	N
7	1.5	Preliminary Network Submission Deadline	N	N
8	1.6	Detailed Network Submission Deadline	N	N
9	1.7	Review and Approval Process	N	N
10	1.8	Cost of Planning/Scheduling and Monitoring	Y	N
11	1.9	Progress Payments for Planning/Scheduling and Monitoring	Y	N
12	1.10	Subcontractor Input	N	N
13	1.11	Contractor's Scheduling Plan	N	N
14	1.12	Planning/Scheduling and Monitoring Audits	N	N
15	1.13	Confidentiality/Schedule Ownership	Y	N
16	1.14	Computer Access and Security	N	N
17	2.1	Network Analysis Technique	N	N
18	2.2	CPM Software (or equal) to be Used	Y	N
19	2.3.1	Activity Description	N	Y
20	2.3.2	Activity Duration (Time Units)	N	Y
21	2.3.3	Activity Coding System	N	N
22	2.3.4	Responsibility Codes	N	N
23	2.3.5	Activity Level Resources	N	N
24	2.3.6	Project Level Resources	N	N
25	2.3.7	Activity Costs	N	N
26	2.3.8	Work Calendars	N	Y
27	2.4.1	Maximum Activity Duration	N	N
28	2.4.2	Maximum Activity Costs	N	N
29	2.4.3	Minimum Number of Activities in the Completed Network	N	N
30	2.4.4	Minimum Number of Activities in the Preliminary Network	N	N
31	2.5.1	Summary Schedule	N	Y
32	2.5.2	Preliminary Network	Y	Y
33	2.5.3	Detailed Network	N	Y
34	2.6	Project Breakdown Structure	N	N
35	2.7	Milestones and Imposed Dates	Y	N
36	2.8	Activity Sorting Requirements	N	N
37	2.9	Drafting Requirements	N	N
38	2.10	Required Reports for Initial Submittal of Completed Network	N	N
39	2.11.1	Resource Aggregation	N	N
40	2.11.2	Resource Leveling	N	N
41	2.11.3	Resource Allocation Optimization	N	N
42	3.1	Updating Fequency	N	Y
43	3.2	Updating Participation	N	Y
44	3.3	Updatd Network Approval	N	Y

	E	F	G	H	I	J	K	L	M	N	O
1 2	Ctr-C	Ctr-E	Own-A	Own-B	Nav-B	Nav-C	Nav-D	Nav-E	Nav-F	Nav-G	Nav-H
3	N	N	Y	N	Y	Y	N	Y	N	Y	Y
4	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y
5	N	N	N	N	N	U	U	Y	N	N	N
6	N	N	N	N	N	N	U	N	N	N	N
7	N	N	Y	N	N	Y	N	Y	N	Y	N
8	Y	N	Y	N	Y	U	N	Y	N	Y	N
9	Y	N	N	N	U	N	Y	N	N	Y	N
10	N	N	N	N	N	N	Y	N	N	N	N
11	N	N	N	N	N	N	Y	N	N	N	Y
12	U	N	N	N	N	N	Y	N	N	N	N
13	N	N	N	N	N	N	N	N	N	N	Y
14	N	N	N	N	N	U	Y	N	N	Y	N
15	Y	N	Y	U	U	N	N	N	N	N	N
16	N	N	Y	U	Y	N	N	Y	N	N	N
17	N	N	Y	N	Y	Y	Y	Y	N	N	N
18	N	N	Y	Y	Y	N	Y	Y	N	Y	N
19	Y	N	Y	Y	U	Y	N	Y	N	Y	N
20	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N
21	Y	N	Y	Y	N	Y	N	Y	N	Y	N
22	Y	N	N	Y	Y	U	N	Y	N	Y	N
23	Y	N	N	Y	Y	U	N	U	N	N	N
24	Y	N	N	U	U	U	N	U	N	N	N
25	Y	N	Y	Y	Y	Y	N	N	N	Y	N
26	Y	N	Y	Y	U	Y	N	N	N	Y	N
27	N	N	N	U	U	Y	N	Y	N	Y	N
28	N	N	N	U	U	N	N	N	N	Y	N
29	N	N	U	N	N	N	N	Y	N	Y	N
30	N	N	U	N	Y	N	N	Y	N	Y	N
31	N	N	N	N	Y	N	N	N	N	Y	N
32	N	N	N	N	Y	N	N	Y	N	Y	N
33	N	N	N	Y	Y	N	Y	Y	N	N	N
34	N	N	U	Y	U	N	N	U	N	N	N
35	N	N	Y	N	U	N	Y	N	N	N	N
36	N	N	Y	Y	N	Y	N	Y	N	N	N
37	N	N	U	U	Y	Y	Y	N	N	N	N
38		N	Y	Y	N	Y	N	U	N	N	N
39	N	N	N	U	N	N	N	N	N	N	N
40	N	N	N	Y	U	N	N	N	N	N	N
41	N	N	N	U	N	N	N	N	N	N	N
42	N	N	Y	Y	U	Y	Y	Y	N	Y	N
43	N	N	Y	Y	U	N	Y	N	N	Y	N
44	N	N	Y	Y	U	Y	Y	N	N	Y	N

	P	Q	R	S
1	Totals			Clause
2	Yes	Und	No	Desirability
3	7	0	6	1.615
4	9	0	4	2.077
5	1	2	10	0.462
6	0	1	12	0.115
7	4	0	9	0.923
8	5	1	7	1.269
9	3	1	9	0.808
10	2	0	11	0.462
11	3	0	10	0.692
12	1	1	11	0.346
13	1	0	12	0.231
14	2	1	10	0.577
15	3	2	8	0.923
16	3	1	9	0.808
17	5	0	8	1.154
18	7	0	6	1.615
19	7	1	5	1.731
20	9	0	4	2.077
21	6	0	7	1.385
22	5	1	7	1.269
23	3	2	8	0.923
24	1	4	8	0.692
25	6	0	7	1.385
26	6	1	6	1.500
27	3	2	8	0.923
28	1	2	10	0.462
29	2	1	10	0.577
30	3	1	9	0.808
31	3	0	10	0.692
32	5	0	8	1.154
33	5	0	8	1.154
34	1	3	9	0.577
35	3	1	9	0.808
36	4	0	9	0.923
37	3	2	8	0.923
38	3	1	8	0.875
39	0	1	12	0.115
40	1	1	11	0.346
41	0	1	12	0.115
42	7	1	5	1.731
43	5	1	7	1.269
44	6	1	6	1.500

	A	B	C	D
45	3.4	Updating Turnover Time	N	Y
46	3.5	Updating Records and Reporting	N	Y
47	3.6	Float Management	N	Y
48	3.7.1	Change Order Representation	N	N
49	3.7.2	Change Order Summary/Documentation	N	N
50	3.7.3	Timing of Change Order Incorporation	N	N
51	3.8	Required Reports at Each Update	N	N
52		Specification Desirability	0.367	0.857

	E	F	G	H	I	J	K	L	M	N	O
45	N	N	Y	Y	U	N	Y	Y	N	Y	N
46	N	N	U	Y	U	N	Y	Y	N	N	N
47	N	N	Y	N	Y	N	Y	N	N	Y	N
48	N	N	Y	Y	Y	Y	Y	Y	N	N	N
49	N	N	N	N	Y	Y	Y	Y	N	N	N
50	N	N	Y	U	Y	Y	Y	Y	N	N	N
51	N	N	Y	Y	U	N	Y	Y	N	N	N
52	0.781	0.000	1.622	1.561	1.653	1.224	1.408	1.653	0.000	1.469	0.245

	P	Q	R	S
45	6	1	6	1.500
46	4	2	7	1.154
47	5	0	8	1.154
48	6	0	7	1.385
49	4	0	9	0.923
50	5	1	7	1.269
51	4	1	8	1.038
52	3.837	0.878	8.265	0.988

Appendix I

Contingency Tables for Clauses for Lump Sum Projects

Contingency Table for Clause Number 1.1

Clause Title: Description, References, Standards		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	13 (9.4)	2 (5.6)	15
	Medium	8 (8.8)	6 (5.2)	14
	Low	6 (8.8)	8 (5.2)	14
	Totals	27	16	43
	χ^2	6.23		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.381		

Contingency Table for Clause Number 1.3

Clause Title: Minimum Qualifications of Planning and Scheduling Staff		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	13 (6.6)	2 (8.4)	15
	Medium	5 (6.2)	9 (7.8)	14
	Low	5 (6.2)	13 (7.8)	14
	Totals	19	24	43
	χ^2	19.17		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.668		

Contingency Table for Clause Number 1.5

Clause Title: Preliminary Network Submission Deadline		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	15 (8.7)	0 (6.2)	15
	Medium	7 (8.1)	7 (5.9)	14
	Low	3 (8.1)	11 (5.9)	14
	Totals	25	18	43
	χ^2	18.93		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.664		

Contingency Table for Clause Number 1.7

Clause Title: Review and Approval Process		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	13 (8.4)	2 (6.6)	15
	Medium	7 (7.8)	7 (6.2)	14
	Low	4 (7.8)	10 (6.2)	14
	Totals	24	19	43
	χ^2	5.99		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.373		

Contingency Table for Clause Number 1.10

Clause Title: Subcontractor Input		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (7.0)	3 (8.0)	15
	Medium	5 (6.5)	9 (7.5)	14
	Low	3 (6.5)	11 (7.5)	14
	Totals	20	23	43
	χ^2	10.96		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.505		

Contingency Table for Clause Number 2.3.5

Clause Title: Activity Level Resources		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	9 (7.3)	6 (7.6)	15
	Medium	8 (6.8)	6 (7.2)	14
	Low	4 (6.8)	10 (7.2)	14
	Totals	21	22	43
	χ^2	3.44		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.283		

Contingency Table for Clause Number 2.3.7

Clause Title: Activity Costs		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	10 (8.7)	5 (6.2)	15
	Medium	9 (8.1)	5 (5.9)	14
	Low	6 (8.1)	8 (5.9)	14
	Totals	25	18	43
	χ^2	2.01		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.216		

Contingency Table for Clause Number 2.4.1

Clause Title: Maximum Activity Duration		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 ()	3 ()	15
	Medium	10 ()	4 ()	14
	Low	3 ()	11 ()	14
	Totals	25	18	43
	χ^2	11.71		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.522		

Contingency Table for Clause Number 2.4.3

Clause Title: Minimum No. of Activities in the Completed Network		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	9 (5.2)	6 (9.8)	15
	Medium	4 (4.9)	10 (9.1)	14
	Low	2 (4.9)	12 (9.1)	14
	Totals	15	28	43
	χ^2	7.03		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.404		

Contingency Table for Clause Number 2.4.4

Clause Title: Minimum No. of Activities in the Preliminary Network		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	9 (6.0)	6 (9.0)	15
	Medium	5 (5.5)	9 (8.5)	14
	Low	3 (5.5)	11 (8.5)	14
	Totals	17	26	43
	χ^2	4.63		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.328		

Contingency Table for Clause Number 2.5.1

Clause Title: Summary Schedule		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.4)	3 (6.6)	15
	Medium	9 (7.8)	5 (6.2)	14
	Low	3 (7.8)	11 (6.2)	14
	Totals	24	19	43
	χ^2	10.68		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.498		

Contingency Table for Clause Number 2.5.2

Clause Title: Preliminary Network		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.4)	3 (6.6)	15
	Medium	7 (7.8)	7 (6.2)	14
	Low	5 (7.8)	9 (6.2)	14
	Totals	24	19	43
	χ^2	6.04		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.375		

Contingency Table for Clause Number 2.7

Clause Title: Milestones and Imposed Dates		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (8.4)	4 (6.6)	15
	Medium	9 (7.8)	5 (6.2)	14
	Low	4 (7.8)	10 (6.2)	14
	Totals	24	19	43
	χ^2	6.49		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.388		

Contingency Table for Clause Number 2.9

Clause Title: Drafting Requirements		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (7.3)	4 (7.6)	15
	Medium	7 (6.8)	7 (7.2)	14
	Low	3 (6.8)	11 (7.2)	14
	Totals	21	22	43
	χ^2	7.82		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.426		

Contingency Table for Clause Number 2.10

Clause Title: Reqrd. Rep. for Initial Submtl of Completed Network		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (7.7)	2 (6.3)	14
	Medium	7 (7.1)	6 (5.9)	13
	Low	3 (7.1)	10 (5.9)	13
	Totals	22	18	40
	χ^2	10.70		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.517		

Contingency Table for Clause Number 3.2

Clause Title: Updating Participation		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (9.4)	3 (5.6)	15
	Medium	9 (8.8)	5 (5.2)	14
	Low	6 (8.8)	8 (5.2)	14
	Totals	27	16	43
	χ^2	4.30		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.316		

Contingency Table for Clause Number 3.3

Clause Title: Updated Network Approval		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (9.0)	4 (5.9)	15
	Medium	9 (8.5)	5 (5.5)	14
	Low	5 (8.5)	8 (5.5)	14
	Totals	26	17	43
	χ^2	2.94		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.261		

Contingency Table for Clause Number 3.4

Clause Title: Updating Turnover Time		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	13 (10.1)	2 (4.8)	15
	Medium	9 (9.4)	5 (4.6)	14
	Low	7 (9.4)	7 (4.6)	14
	Totals	29	14	43
	χ^2	4.53		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.325		

Contingency Table for Clause Number 3.5

Clause Title: Updating Records and Reporting		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (8.4)	4 (6.6)	15
	Medium	8 (7.8)	6 (6.2)	14
	Low	5 (7.8)	9 (6.2)	14
	Totals	24	19	43
	χ^2	4.17		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.311		

Contingency Table for Clause Number 3.6

Clause Title: Float Management		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (9.0)	3 (5.9)	15
	Medium	9 (8.5)	5 (5.5)	14
	Low	5 (8.5)	9 (5.5)	14
	Totals	26	17	43
	χ^2	6.07		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.376		

Contingency Table for Clause Number 3.7.2

Clause Title: Change Order Summary/Documentation		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	14 (9.4)	1 (5.6)	15
	Medium	9 (8.8)	5 (5.2)	14
	Low	4 (8.8)	10 (5.2)	14
	Totals	27	16	43
	χ^2	13.02		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.550		

Contingency Table for Clause Number 3.7.3

Clause Title: Timing of Change Order Incorporation		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.7)	3 (6.3)	15
	Medium	8 (8.1)	6 (5.9)	14
	Low	5 (8.1)	9 (5.9)	14
	Totals	25	18	43
	χ^2	5.84		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.369		

Contingency Table for Clause Number 3.8

Clause Title: Required Reports at Each Update		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.4)	3 (6.6)	15
	Medium	7 (7.8)	7 (6.2)	14
	Low	5 (7.8)	9 (6.2)	14
	Totals	24	19	43
	χ^2	6.04		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.375		

Appendix J

Contingency Tables for Clauses for Cost Reimbursable Projects

Contingency Table for Clause Number 1.3

Clause Title: Minimum Qualifications of Planning and Scheduling Staff		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (6.0)	2 (8.0)	14
	Medium	4 (5.5)	9 (7.5)	13
	Low	1 (5.5)	12 (7.5)	40
	Totals	17	23	
	χ^2	17.88		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.669		

Contingency Table for Clause Number 1.5

Clause Title: Preliminary Network Submission Deadline		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	14 (8.8)	0 (5.2)	14
	Medium	7 (8.1)	6 (4.9)	13
	Low	4 (8.1)	9 (4.9)	13
	Totals	25	15	40
	χ^2	14.40		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.600		

Contingency Table for Clause Number 1.7

Clause Title: Review and Approval Process		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (7.4)	2 (6.6)	14
	Medium	6 (6.8)	7 (6.2)	13
	Low	3 (6.8)	10 (6.2)	13
	Totals	21	19	40
	χ^2	10.92		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.522		

Contingency Table for Clause Number 1.10

Clause Title: Subcontractor's Input		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (6.0)	2 (8.0)	14
	Medium	4 (5.5)	9 (7.5)	13
	Low	1 (5.5)	12 (7.5)	13
	Totals	17	23	40
	χ^2	17.88		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.669		

Contingency Table for Clause Number 2.3.5

Clause Title: Activity Level Resources		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	9 (6.6)	5 (7.4)	14
	Medium	7 (6.2)	6 (6.8)	13
	Low	3 (6.2)	10 (6.8)	13
	Totals	19	21	40
	χ^2	4.90		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.350		

Contingency Table for Clause Number 2.3.7

Clause Title: Activity Costs		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (9.1)	3 (4.9)	14
	Medium	9 (8.4)	4 (4.5)	13
	Low	6 (8.4)	7 (4.5)	13
	Totals	26	14	40
	χ^2	3.27		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.286		

Contingency Table for Clause Number 2.4.1

Clause Title: Maximum Activity Duration		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (8.0)	3 (6.0)	14
	Medium	9 (7.5)	4 (5.5)	13
	Low	3 (7.5)	10 (5.5)	13
	Totals	23	17	40
	χ^2	9.58		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.489		

Contingency Table for Clause Number 2.4.3

Clause Title: Minimum No. of Activities in the Completed Network		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	9 (5.2)	5 (8.8)	14
	Medium	4 (4.9)	9 (8.1)	13
	Low	2 (4.9)	11 (8.1)	13
	Totals	15	25	40
	χ^2	7.25		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.426		

Contingency Table for Clause Number 2.4.4

Clause Title: Minimum Number of Activities in Prelim. Network		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	9 (6.0)	5 (8.0)	14
	Medium	5 (5.5)	8 (7.5)	13
	Low	3 (5.5)	10 (7.5)	13
	Totals	17	23	40
	χ^2	4.81		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.347		

Contingency Table for Clause Number 2.5.1

Clause Title: Summary Schedule		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.0)	2 (6.0)	14
	Medium	8 (7.5)	5 (5.5)	13
	Low	3 (7.5)	10 (5.5)	13
	Totals	23	17	40
	χ^2	10.95		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.523		

Contingency Table for Clause Number 2.5.2

Clause Title: Preliminary Network		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.8)	2 (5.2)	14
	Medium	8 (8.1)	5 (4.9)	13
	Low	5 (8.1)	8 (4.9)	13
	Totals	25	15	40
	χ^2	6.43		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.401		

Contingency Table for Clause Number 2.7

Clause Title: Milestones and Imposed Dates		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	10 (7.4)	4 (6.6)	14
	Medium	8 (6.8)	5 (6.2)	13
	Low	3 (6.8)	10 (6.2)	13
	Totals	21	19	40
	χ^2	6.95		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.417		

Contingency Table for Clause Number 2.9

Clause Title: Drafting Requirements		*Clause Desirability Rating* **Yes**	**Und/No**	**Totals**
Project Complexity Rating	**High**	10 (6.6)	4 (7.4)	14
	Medium	6 (6.2)	7 (6.8)	13
	Low	3 (6.2)	10 (6.8)	13
	Totals	19	21	40
	χ^2	6.33		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.398		

Contingency Table for Clause Number 2.10

Clause Title: Reqrd. Rep. for Initial Submtl of Completed Network		*Clause Desirability Rating* **Yes**	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (7.0)	2 (6.0)	13
	Medium	6 (6.5)	6 (5.5)	12
	Low	3 (6.5)	9 (5.5)	12
	Totals	20	17	37
	χ^2	9.05		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.494		

Contingency Table for Clause Number 3.2

Clause Title: Updating Participation		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	13 (8.8)	1 (5.2)	14
	Medium	7 (8.1)	6 (4.9)	13
	Low	5 (8.1)	8 (4.9)	13
	Totals	25	15	40
	χ^2	9.13		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.478		

Contingency Table for Clause Number 3.3

Clause Title: Updated Network Approval		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (8.4)	3 (5.6)	14
	Medium	7 (7.8)	6 (5.2)	13
	Low	6 (7.8)	7 (5.2)	13
	Totals	24	16	40
	χ^2	3.26		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.285		

Contingency Table for Clause Number 3.4

Clause Title: Updating Turnover Time		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	13 (9.1)	1 (4.9)	14
	Medium	7 (8.4)	6 (4.5)	13
	Low	6 (8.4)	7 (4.5)	13
	Totals	26	14	40
	χ^2	7.52		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.433		

Contingency Table for Clause Number 3.5

Clause Title: Updating Records and Reporting		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	11 (7.4)	3 (6.6)	14
	Medium	6 (6.8)	7 (6.2)	13
	Low	4 (6.8)	9 (6.2)	13
	Totals	21	19	40
	χ^2	6.49		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.403		

Contingency Table for Clause Number 3.6

Clause Title: Float Management		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.8)	2 (5.2)	14
	Medium	8 (8.1)	5 (4.9)	13
	Low	5 (8.1)	8 (4.9)	13
	Totals	25	15	40
	χ^2	6.43		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.401		

Contingency Table for Clause Number 3.7.2

Clause Title: Change Order Summary/Documentation		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	14 (9.1)	0 (4.9)	14
	Medium	8 (8.4)	5 (4.5)	13
	Low	4 (8.4)	9 (4.5)	13
	Totals	26	14	40
	χ^2	14.30		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.598		

Contingency Table for Clause Number 3.7.3

Clause Title: Timing of Change Order Incorporation		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (8.4)	2 (5.6)	14
	Medium	7 (7.8)	6 (5.2)	13
	Low	5 (7.8)	8 (5.2)	13
	Totals	24	16	40
	χ^2	6.58		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.405		

Contingency Table for Clause Number 3.8

Clause Title: Required Reports at Each Update		*Clause Desirability Rating*		
		Yes	**Und/No**	**Totals**
Project Complexity Rating	**High**	12 (7.7)	2 (6.3)	14
	Medium	6 (7.1)	7 (5.9)	13
	Low	4 (7.1)	9 (5.9)	13
	Totals	22	18	40
	χ^2	8.83		
	χ^2 **critical**	5.99		
	Cramer's *V*	0.470		

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